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# THE VIRGINIA JOURNAL OF SCIENCE

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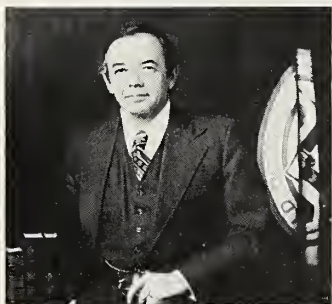
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The commitment of Old Dominion University to the ideal of an urban university influences the nature of research and related forms of scholarly endeavor undertaken by its faculty. While basic or pure research is encouraged, emphasis is placed on applied research because of the University's special responsibilities to the region which it serves. We at Old Dominion University welcome the opportunity to provide a headquarters and support for the *Virginia Journal of Science*.

We share a common mission with the Virginia Academy of Science. Through creation and propagation of new knowledge, we strive to improve the quality of life and serve our society. The *Virginia Journal of Science* provides an important means for pursuing that goal.

The *Virginia Journal of Science* covers all disciplines in science and engineering, including agricultural and health professions. We understand that the new editor will emphasize articles dealing with scientific and technological developments and their impact on man and his environment. We encourage this effort by bringing together the natural and social sciences to address our major problems.

The Virginia Polytechnic Institute and State University and the Medical College of Virginia have raised and nurtured this great publication through its infancy. We are proud to have the opportunity to follow the noble traditions of our two sister institutions of higher learning in helping the Journal through its next phase of mature development.

With this issue of the *Virginia Journal of Science*, the first for our new editor and the first from its new home, Old Dominion University, we are approaching the end of the Academy year. It is time to assess our accomplishments during the year and plans for the future. Certainly, the progress which has been made with regard to the appointment of an excellent editorial board and journal staff, the new format and plans for new features, and the excellent support being provided by Old Dominion University promise a bright future for the Journal.

For several years each Fall, the Science Education Committee has planned science teacher workshops in conjunction with the science teachers' conference. At the last conference held in Williamsburg, Dr. Arthur Burke and Virginia Ellet, cochairmen of the Committee, planned an excellent workshop dealing with our energy resources. We hope this program shall continue and expand.

The Academy serves in an advisory capacity to the state and local governments on scientific matters. Our Ad Hoc Science Advisory Committee, under stewardship of Dr. Ertle Thompson, had a busy year, especially with regard to environmental problems. We expect an expanded role for this important committee, and steps are being taken to make it a standing committee.

The Fund-Raising Committee, chaired by Dr. Samuel Gillespie, was reinstated this year. Its primary function is to increase our trust fund which provides modest research grants for scientists at small colleges who would otherwise face hardships.

The Academy has contributed, probably more than any other organization, to efforts leading to the creation of the Science Museum in Virginia. Several Academy members serve as trustees, with Dr. Rae Carpenter as the Chairman of the Board. The Discovery Room, the first phase of the Museum Development, opened this year and provides a hands-on exhibit which has proved very popular.

I have touched on a few of the Academy activities of a special nature. Other committees and many individuals have made great contributions. It has been a good year, and I sincerely thank all those who contributed to the success of the Academy's programs.



# Chronology of the Roselle Lineament of Southeast Missouri: Rb/Sr Data from a Cataclastic Granite

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## Geologic Setting

The St. Francois Mountains of southeast Missouri form a Precambrian igneous province composed chiefly of high-silica alkalic rhyolites intruded by epizonal granite plutons (Figure 1). These rocks are scattered over an area of about  $10^4$  km<sup>2</sup> which contains about  $10^3$  km<sup>2</sup> of exposed igneous outcrop. Kisvarsanyi (1973) has recently shown from drill-core studies that the Precambrian terrane is much more extensive and heterogeneous than the surface exposures indicate. U/Pb age determinations (Bickford and Mose 1972) indicate that the volcanism and plutonism were approximately contemporaneous about 1.5 b.y. ago. The volcanic rocks are extremely voluminous and include lava flows, air-fall tuffs, major amounts of ash-flow tuff, and a variety of volcanic breccias. Compositionally, the exposed effusive rocks range from andesite to rhyolite with the latter vastly predominant. The plutonic masses range from layered gabbros (Amos and Desborough 1970) to rapakivi granites (Lowell and Sides 1973). Significant quantities of iron ore of Precambrian age (Emery 1968; Snyder 1969) are intimately associated with the silicic volcanic rocks. The petrogenetic relationships between the volcanic rocks, mafic and silicic plutons, and iron ores are poorly understood and constitute major unresolved problems.

Although very small, the St. Francois Mountains igneous province is of significant geologic importance because: (1) it is the exposed portion of a distinctive major Precambrian belt which forms an arcuate margin about the North American craton (Muehlberger et al. 1966; Lidiak et al. 1966; Bickford and Van Schmus 1973); (2) it is the only extensively exposed area of unmetamorphosed Precambrian ash-flow tuff in North America (J. E. Anderson et al. 1969); (3) it contains the only documented caldera of Precambrian age in North America (J. E. Anderson et al. 1969); (4) it is broken by a major crustal lineament (Gillerman 1970; Lowell et al. 1973); (5) it contains economic deposits of magmatic iron ore (Snyder 1969); and (6) Precambrian basement structures may have exerted considerable influence on the distribution of major Phanerozoic ore bodies in the southeast Missouri lead belt and Illinois-Kentucky fluorspar district (Heyl et al. 1965; Gillerman 1970; Lowell et al. 1973).

**Abstract**— The Roselle lineament in southeast Missouri is a zone of strike-slip faulting along which Precambrian and Paleozoic rocks are displaced. Rb/Sr isotopic analyses of minerals in a sample of Butler Hill granite from within the fault zone are compared with analyses of minerals in an undeformed sample. Both sets of minerals yield mineral isochrons with a calculated age of about 1300 m.y., indicating that cataclasis of the granite was insufficient to cause strontium isotopic homogenization.

## Introduction

Recently, Gillerman (1970) drew attention to the existence of a previously unknown structure in southeast Missouri which he named the Roselle lineament. The lineament comprises a remarkable alignment of topographic and structural features which trend N. 0–10° E. from a point in southeast Missouri near the Arkansas border, through the southeast Missouri lead belt to a point northeast of St. Louis, Missouri. The lineament is about 200 km long and is intersected but not displaced by the major E-W trending 38th parallel lineament (Heyl 1972) between the Missouri cities of Farmington and Crystal City (Lowell et al. 1973).

In a number of recent studies (Dietrich et al. 1969; Turek and Peterman 1971; Ratcliffe et al. 1972; Abbott 1972; Odom and Fullagar 1973; Pankhurst 1974), Rb/Sr isotopic data have been applied to the problem of determining the timing of tectonic events. In this study, the last period of isotopic homogenization is determined for a partially recrystallized granite microbreccia from a faulted segment of the Roselle lineament in the St. Francois Mountains of southeast Missouri.

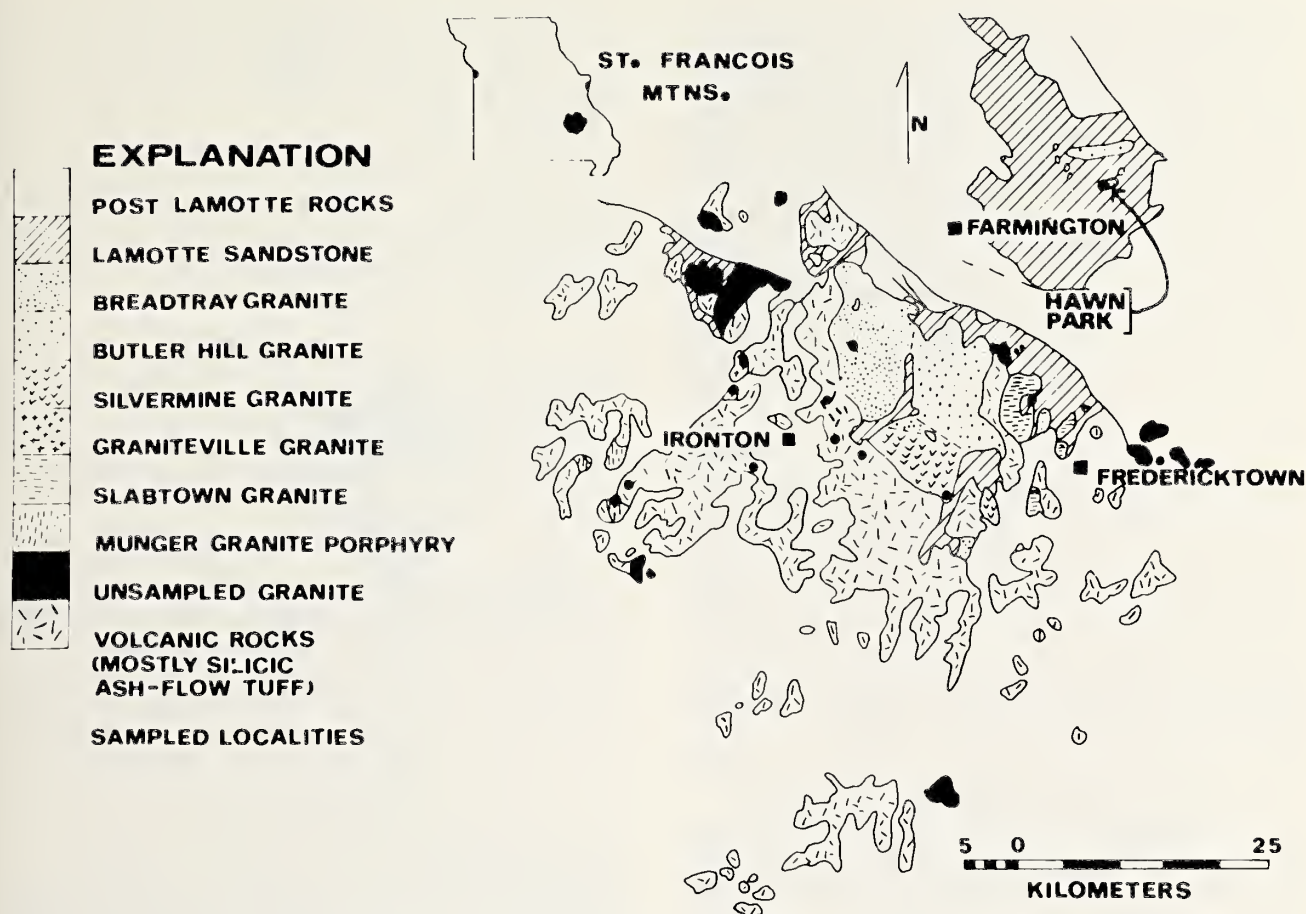


FIG. 1—Geologic map of the St. Francois Mountains (Bickford and Mose, 1975).

### Roselle Lineament

Gillerman (1970) recently demonstrated the existence of a major lineament in southeast Missouri which he named the Roselle lineament (Figure 2). The principal elements of this lineament are (1) alignment of stream segments; (2) a buried Precambrian scarp; (3) the Roselle fault; (4) the Platin anticline; and (5) the course of the Mississippi River north of Crystal City (Gillerman 1970). These features form an almost continuous lineament extending more than 200 km from southwest of Poplar Bluff, where the lineament is obscured by the Mississippi Embayment, to a point near the confluence of the Missouri and Mississippi Rivers.

The southeast Missouri mineral district occurs near the intersection of the north-northeast trending Roselle lineament and the east-west trending 38th parallel lineament (Lowell et al. 1973) amidst a complex network of faults bordered on the south and north respectively by the northwest trending Sims Mountain and Ste. Genevieve faults zones and on the west by the northeast trending Big River fault. According to Heyl (1972, p. 889) many of these faults developed during Precambrian time and were reactivated with predominantly strike-slip displacement during Paleozoic time prior to Pb-Zn mineralization. At least 70 kimberlite to alkalic peridotite diatremes and dikes of Devonian age (Zartman et al. 1967)

occur in a swarm just to the east of the lineament in the vicinity of Avon, Missouri. A number of these ultramafic bodies contain postigneous galena, sphalerite, fluorite, and barite (Heyl 1972, p. 888).

The portion of the Roselle lineament passing through the St. Francois Mountains was designated as the Roselle fault by Gillerman (1970, p. 975) and was the subject of a recent study by Lowell et al. (1973) who concluded that the Roselle fault is strike-slip in nature with a sinistral displacement in Precambrian time of at least 6 km. Lowell et al. (1973) also indicated that at least some tectonic movement occurred along the fault in post-Late Cambrian time based upon deformational features within the Bonnetterre Formation north and south of the exposed batholithic terrane. Of major interest here is a cataclastic zone between the Breadtray and Butler Hill granites, both approximately 1.5 b.y. in age (Bickford and Mose 1972), defined by the presence of thoroughly crushed and partially recrystallized Butler Hill granite (Lowell et al. 1973).

### Cataclasis in the Butler Hill Granite

The igneous rock chosen for isotopic study belongs to the unit mapped as Butler Hill granite by Tolman and Robertson (1969). One deformed sample of Butler Hill granite was obtained for isotopic analysis



from the cataclastic zone along the Roselle lineament described by Lowell and Sides (1973).

Normal undeformed Butler Hill granite is a pink to gray, medium-grained to coarsely porphyritic, hypidiomorphic orthoclase granite which is locally characterized by the development of rapakivi texture (Lowell and Sides 1973). The existing chemical and modal data on the Butler Hill granite has been tabulated by Kisvarsanyi (1972). Outcrop characteristics include minor cross-cutting aplite dikes, occasional small pods and stringers of simple pegmatite, miarolitic cavities containing fluorite, quartz, calcite, and chlorite, and, in some localities, mafic to rhyolitic xenoliths. One sample of undeformed Butler Hill rapakivi granite was isotopically analyzed in this study.

The deformed sample analyzed in this study was obtained along the contact between the Butler Hill and Breadtray granites which was described as gradational by Tolman and Robertson (1969, p. 41). Subsequently, Lowell et al. (1973) determined that this gradational effect was produced by cataclasis along the Roselle fault. A pronounced valley has formed along the cataclastic zone in which outcrops are generally rather poor. At the sample locality, normal undeformed Butler Hill granite grades into dark crushed lenses with pink streaky zones of chaotic angular fragments. Small quartz veinlets containing granite fragments cut across the cataclastic lenses and, in turn, are cut by trains of pyrite cubes.

In thin section, brecciation and recrystallization are both evident with the former predominant. No fluxion structure was observed in any of the sections studied, suggesting that brecciation was not followed by milling and laminar flowage. An extreme range of particle sizes are present (up to 5 mm), but more than 30 percent of the angular fragments are over 0.2 mm in size; thus, according to Higgins (1971, p. 3), the cataclastic granite is a partially recrystallized microbreccia. In the terminology proposed by Spry (1969, p. 229), the rock would be termed protocataclasite. Typically, the texture consists of rounded to lenticular relict aggregates of interlocking quartz and feldspar set in a matrix of crushed angular fragments of the same minerals. Quartz is present as crushed, angular and flamboyant, undulose grains and as homogeneous recrystallized grains in relict aggregates and veinlets cutting plagioclase and orthoclase microperthite. Plagioclase displays offset twin lamellae, twin lamellae which pinch and swell, and kinks in the twin lamellae. Much of the plagioclase is altered to sericite. Orthoclase microperthite displays an idiomorphic tendency but is highly fractured. Undulant extinction is common in the orthoclase, and microclinization is widespread. A small amount (1 to 2 percent) of chloritized green biotite and a few grains of muscovite cut across feldspar and quartz grain boundaries. Zircon is a common accessory mineral, and trains of fluid inclusions are quite prominent in the feldspars.

#### Analytical Procedure

Two samples weighing approximately 10 kg each were collected from the Butler Hill granite, one from

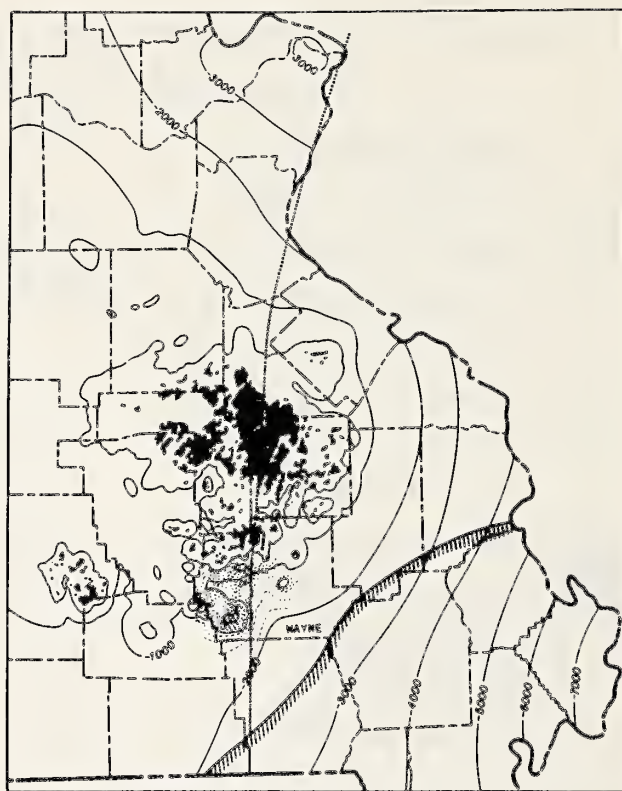


FIG. 2—Map showing the Precambrian surface and the Roselle lineament (Gillerman, 1971).

outside and one from inside the cataclastic zone. Both were split in half after they were crushed. One half was split down to approximately one-half gram and used for the whole-rock analysis; one half was used for mineral separation.

Each whole-rock split and mineral separate was spiked with  $^{84}\text{Sr}$  and  $^{87}\text{Rb}$  prior to dissolution in approximately 25 ml of HF and 0.5 ml of doubly distilled  $\text{HClO}_4$ . Sample digestions were done in 50 ml Teflon beakers. The samples were taken up in 3N HCl and passed through cation exchange resin columns to obtain Rb and Sr fractions for isotopic analysis.

The mass spectrometric analyses were done with the mass spectrometer in the Department of Geology at Florida State University. This instrument is a 12-inch radius of curvature,  $60^\circ$  sector, single-focusing mass spectrometer with a triple-filament thermionic source, Faraday cup collector, vibrating reed electrometer and expanded scale stripchart recorder.

At FSU, the Eimer and Amend Standard  $\text{SrCO}_3$  (Lot No. 492327) has been analyzed 12 times, yielding an average  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of  $0.7080 \pm 0.0003$  ( $1\sigma$ ) when  $^{86}\text{Sr}/^{88}\text{Sr}$  is normalized to 0.1194. The average blank values during this investigation were  $0.08\mu\text{g}$  Sr and  $0.003\mu\text{g}$  Rb. Compared to the Rb and Sr concentrations in the samples analyzed, the blank values are not significant.

All the Sr isotopic compositions were calculated from analyses of the sample Sr and spike Sr mixture. The  $^{85}\text{Rb}/^{87}\text{Rb}$  ratio was taken to be 2.593 (Catanzaro et al. 1969), and the decay constant used for  $^{87}\text{Rb}$  is  $1.39 \times 10^{-11} \text{ yr}^{-1}$ . The age determinations and

TABLE 1  
Isotopic Analyses of Butler Hill Granite Samples

SAMPLE	( $^{87}\text{Sr}/^{86}\text{Sr}$ )*N	$^{87}\text{Rb}$ ppm	$^{86}\text{Sr}$ ppm	$^{87}\text{Rb}/^{86}\text{Sr}$ (atomic ratio)
Undeformed Butler Hill Granite				
Whole-rock	$0.8560 \pm 0.0013$	66.4194	8.4190	7.7988
Orthoclase	$1.0272 \pm 0.0018$	147.5184	8.1562	17.8793
Plagioclase	$0.8092 \pm 0.0017$	46.5213	9.5215	4.8299
Biotite	$0.8706 \pm 0.0013$	146.4749	13.9970	10.3447
Deformed Butler Hill Granite				
Whole-rock	$0.8774 \pm 0.0007$	29.8547	3.2471	10.2059
Orthoclase	$1.1475 \pm 0.0026$	109.6291	4.6138	23.4887
(50-70 mesh)	$1.1250 \pm 0.0011$	111.6070	5.0346	21.9138
Orthoclase	$1.1453 \pm 0.0024$	113.8110	4.7363	23.7540
(70-100 mesh)	$1.1516 \pm 0.0017$	119.8391	5.0601	23.4116
Plagioclase	$0.8365 \pm 0.0014$	27.4278	3.9077	6.9384

\* Corrected for fractionation, assuming  $^{86}\text{Sr}/^{88}\text{Sr} = 0.1194$ .

initial  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios on the isochron diagrams are visual best-fit lines. The analytical error for the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios of the whole-rocks and mineral separates in Table 1 are given as  $1\sigma$ , and these errors are derived from the mass spectrometric data. Based on other replicate analyses, the estimate of the error on the  $^{87}\text{Rb}/^{86}\text{Sr}$  ratio is 2.0 percent.

### Age Determinations

Rb and Sr concentrations and isotopic ratios for the whole-rock and mineral separates are given in Table 1. Previous whole-rock analyses of the Butler Hill granite yielded an age of  $1408 \pm 72$  m.y. with an initial  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of  $0.7036 \pm 0.0066$ , and zircon separates from the Butler Hill granite using the U/Pb technique yielded an age of  $1495 \pm 20$  m.y. (Bickford and Mose 1975). Within the error limits, the Rb/Sr and U/Pb ages are the same. However, Bickford and

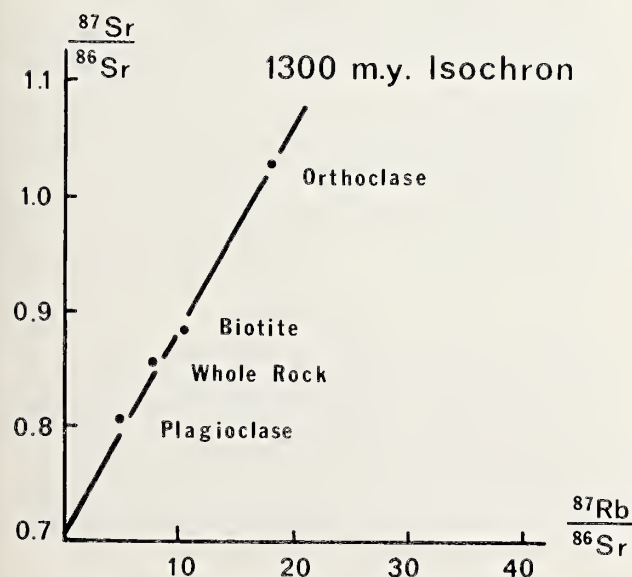
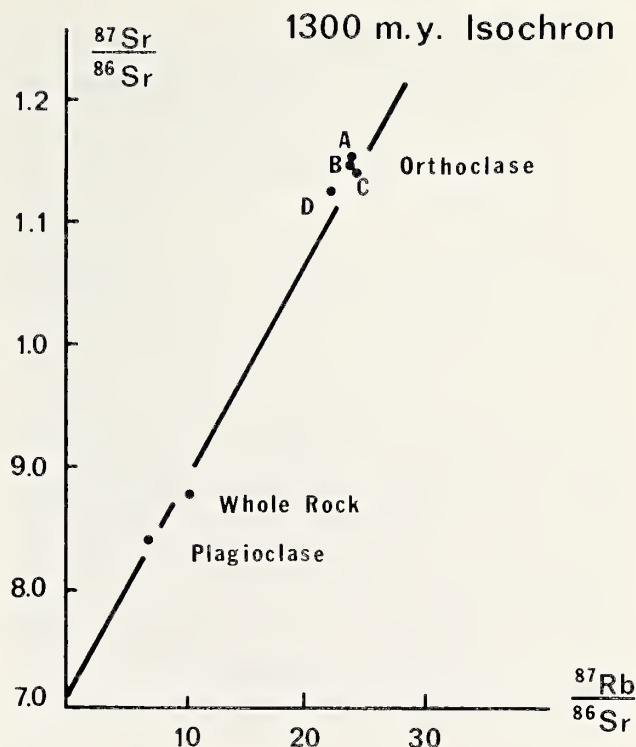


FIG. 3—Rb/Sr isochron diagram derived from an undeformed sample of Butler Hill granite.



### Deformed Butler Hill Granite

FIG. 4—Rb/Sr isochron diagram derived from a deformed sample of Butler Hill granite.

Mose (1975) found that other coeval granitic and volcanic rocks from the St. Francois Mountains yielded U/Pb ages of about 1500 m.y. but Rb/Sr whole-rock isochron ages as young as 1280 m.y. (Bickford and Mose 1972; Mose and Bickford 1972). Bickford and Mose decided that the age of these rocks is about 1500 m.y. and that a subsequent regional event at about 1300 m.y. may be recorded by the younger Rb/Sr ages.

Mineral separates from the undeformed sample of Butler Hill granite yielded a Rb/Sr isochron age of about 1300 m.y. (Figure 3). Mineral separates from a rock from the cataclastic zone in the Butler Hill granite also yield a Rb/Sr isochron age of about 1300 m.y. (Figure 4).

### Summary and Conclusions

Isotopic data from the Butler Hill granite permit the following statements:

- (1) U/Pb analyses show that the plutonic and volcanic episode, which included emplacement of the Butler Hill granite, occurred about 1500 m.y. ago (Bickford and Mose 1975).
- (2) Orthoclase feldspar, plagioclase feldspar, and biotite mineral separates from Butler Hill granite away from the cataclastic zone of the Roselle lineament indicate that the St. Francois Mountains igneous province experienced a period of isotopic homogenization of



the type commonly interpreted as a metamorphic event about 1300 m.y. ago.

- (3) Rb/Sr analyses of orthoclase and plagioclase from Butler Hill granite (recrystallized microbreccia) from a cataclastic zone on the Roselle lineament indicate that these minerals were also last isotopically homogenized about 1300 m.y. ago.

On the basis of the isotopic data, it is concluded that the cataclasis of the Butler Hill granite along the Roselle lineament was insufficient to cause significant isotopic homogenization, and therefore the most recent period of tectonic movement along the lineament cannot be determined by the Rb/Sr method. Petrographically, recrystallization effects appear to be restricted mainly to quartz rather than feldspar; and this is, evidently, reflected by the isotopic data. Fault movement along portions of the Roselle lineament apparently began in late Precambrian time (Gillerman 1970, p. 979); and, judging by existing petrographic data (Lowell et al. 1973), present topographic features (Gillerman 1970), Paleozoic tectonic and magmatic activity in this region (Heyl 1972), and the pattern of recent earthquake epicenters in the Ozark Uplift (Lammlein et al. 1971, Figure 3), is likely to have continued intermittently well into the Paleozoic Era and perhaps much later.

### Acknowledgments

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### Literature Cited

- Abbott, J. T. 1972. Rb-Sr study of isotopic redistribution in a Precambrian mylonite-bearing shear zone, northern Front Range, Colorado. *Geol. Soc. America Bull.* **83**:487-494.
- Amos, D. H., and G. A. Desborough. 1970. Mafic intrusive rocks of Precambrian age in southeast Missouri: Missouri Geol. Survey and Water Resources, R. 1. **47**:22.
- Anderson, J. E., M. E. Bickford, A. W. Berry, and A. L. Odom. 1969. Some age relations and structural features of the Precambrian volcanic terrane, St. Francois Mountains, southeastern Missouri. *Geol. Soc. America Bull.* **80**:1815-1818.
- Bickford, M. E., and W. R. Van Schmus. 1973. Possible middle and late Precambrian igneous arcs in the mid-continent region of North America (abs.). *Geol. Soc. America, North-Central Section, Abstracts with Programs*, **5**:4:300.
- Bickford, M. E., and D. G. Mose. 1972. Chronology of igneous events in the Precambrian of the St. Francois Mountains, southeast Missouri (abs.). *Geol. Soc. America, Abstracts with Programs*, **4**:7:451-452.
- Bickford, M. E., and D. G. Mose. 1975. Geochronology of Precambrian rocks in the St. Francois Mountains, southeast Missouri: *Geol. Soc. America Bull. Spec. Paper* 165.
- Catanzaro, E. J., T. J. Murphy, E. L. Garner and W. R. Shields. 1969. Absolute isotopic abundance ratio and atomic weight of terrestrial rubidium. *J. Res. Nat. Bur. Stand.* **73A**:511-516.
- Dietrich, R. V., P. D. Fullagar, and M. L. Bottion. 1969. K/Ar and Rb/Sr dating of tectonic events in the Appalachians of southwestern Virginia. *Geol. Soc. America Bull.* **80**:307-314.
- Emery, J. A. 1968. Geology of the Pea Ridge iron ore body, in *Ore Deposits of the United States, 1933-1967*, J. R. Ridge, ed. AIME, 359-369.
- Gillerman, E. 1970. Roselle lineament of southeast Missouri. *Geol. Soc. America Bull.* **81**:975-982.
- Heyl, A. V. 1972. The 38th parallel lineament and its relationship to ore deposits. *Econ. Geol.* **67**:879-894.
- Heyl, A. V., M. R. Broek, J. L. Jolly, and C. E. Wells. 1965. Regional structures of the southeast Missouri and Illinois-Kentucky mineral districts. *U. S. Geol. Survey Bull.* **1202-B**:20.
- Higgins, M. W. 1971. Cataclastic rocks. *U. S. Geol. Survey Prof. Paper*, **687**:97.
- Kisvarsanyi, E. 1972. Petrochemistry of a Precambrian igneous province, St. Francois Mountains, Missouri. *Missouri Geol. Survey and Water Resources*, R. 1. **51**:96.
- Kisvarsanyi, E. 1973. Precambrian rocks in the subsurface of Missouri (abs.). *Geol. Soc. America, North-Central Section, Abstracts with Programs*, **5**:4:326-327.
- Lammlein, D. R., M. S. Sbar, and J. Dorman. 1971. A micro-earthquake reconnaissance of southeastern Missouri and western Tennessee. *Bull. Seism. Soc. Am.* **61**:1705-1716.
- Likiak, E. G., R. F. Marvin, H. H. Thomas, and M. N. Bass. 1966. Geochronology of the mid-continent region, United States, pt. 4, eastern area. *J. Geophys. Res.* **71**:5427-5439.
- Lowell, G. R., and J. R. Sides. 1973. Occurrence and origin of rapakivi granite in the St. Francois Mountains batholith of southeast Missouri (abs.). *Geol. Soc. America, North-Central Sec., Abstracts with Programs*, **5**:4:332-333.
- Lowell, G. R., J. R. Sides, and J. L. Yow. 1973. Cataclasis, tectonic mixing and faulting along the Roselle lineament of southeast Missouri (abs.). *Geol. Soc. America, Abstracts with Programs*, **5**:7:718-719.
- Mose, D. G., and M. E. Bickford. 1972. Chronology of Precambrian volcanic rock units in the central St. Francois Mountains, Missouri. *Sectional Reports of the 24th International Geological Congress, Montreal*, **1**:230-237.
- Muehlberger, W. R., C. E. Hedge, R. E. Denison, and R. F. Marvin. 1966. Geochronology of the mid-continent region, United States, pt. 3, southern area. *J. Geophys. Res.* **71**:5409-5426.
- Odom, A. L., and P. D. Fullagar. 1973. Geochronologic and tectonic relationships between the Inner Piedmont, Brevard Zone and Blue Ridge belts, North Carolina: *American J. Sci., Cooper Memorial Volume*, **273-A**:133-149.
- Pankhurst, R. J. 1974. Rb-Sr whole-rock chronology of Caledonia events in northeast Scotland. *Geol. Soc. America Bull.* **85**:345-350.
- Ratcliffe, N. M., R. L. Armstrong, B. Chai and R. G. Senechal. 1972. K-Ar and Rb-Sr geochronology of the Canopus pluton, Hudson Highlands, New York. *Geol. Soc. America Bull.* **83**:523-530.
- Spry, A. 1969. *Metamorphic textures*. Pergamon Press, New York, N. Y., 350 pp.
- Snyder, F. G. 1969. Precambrian iron ore deposits in Missouri, in *Magmatic Ore Deposits*, H. D. B. Wilson, ed. *Econ. Geology, Mono.* **4**:231-238.
- Tolman, C. F., and F. Robertson. 1969. Exposed Precambrian rocks in southeast Missouri. *Missouri Geol. Survey and Water Resources*, R. 1. **44**, 68 pp.
- Turek, A., and Z. E. Peterman. 1971. Advances in the geochronology of the Rice Lake-Beresford Lake area, southeastern Manitoba. *Canadian J. Earth Sci.* **8**:572-579.
- Zartman, R. E., M. Brock, A. V. Heyl, and H. H. Thomas. 1966. K-Ar and Rb-Sr ages of some alkalic intrusive rocks from central and eastern United States. *Geol. Soc. America Spec. Paper* **87**:190-19.

# Effect of Holothurin on *Trypanosoma Duttoni* in Mice Response of Trypanosomes to Biotoxin<sup>1</sup>

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**Abstract**— The effect of holothurin (a marine biotoxin) on the resistance of mice to *Trypanosoma duttoni* was measured by studying changes in the parasite population in vivo. Injection of 0.18 mg of holothurin and  $5 \times 10^4$  trypanosomes affected the level of parasitemia in Swiss Webster male mice at the peak and throughout the course of infection. Mice treated with holothurin prior to and simultaneously with infection of trypanosomes had lower parasitemias than did controls. A higher level of parasitemia was observed in mice treated after infection with trypanosomes. The timing of administration of biotoxin appeared to have been an important parameter of the observed effect. The present study in host-susceptibility and resistance suggests that holothurin or some of its derivatives may have potential pharmacologic properties on hemoflagellate infections in mice.

## Introduction

The development of acquired immunity in rats to *Trypanosoma (Herpetosoma) lewisi* has been studied extensively. In his review of the immunology of the rodent sterocorian trypanosomes, D'Alesandro considered that *T. lewisi* is a valid model for the group as a whole (Targett and Viens 1975). The reproduction-inhibiting factor has been most intensively studied in *T. lewisi* of the rat and *Trypanosoma duttoni* (=mus-

culi) of the mouse (Dusanic 1975). *Trypanosoma duttoni* is regarded as closely related morphologically and systematically to the rat trypanosome *T. lewisi*. Its developmental history in mice has many parallels in *T. lewisi* (Lincicome and Shepperson 1963).

In their study with *T. duttoni*, Lincicome et al. (1965) reported that the BALB/C mouse developed substantially smaller trypanosome populations as compared to the beige mouse. Singer et al. (1964) found that the resistance of mice was enhanced when *Escherichia coli* endotoxin was administered prior to infection with *T. duttoni* and other trypanosomes. Styles (1970) demonstrated that crude holothurin, a biotoxin from the Bahamian sea cucumber *Actinopyga agassiz*, inoculated into rats prior to and simultaneously with an infection of *Trypanosoma lewisi* had lower parasitemias than did controls. A higher level of parasitemia was observed in rats treated after infection with trypanosomes. The active principle or principles in the Bahamian sea cucumber, *A. agassiz*, are concentrated in the cuvierian tubule and were named holothurin by Nigrelli. This substance inhibits growth of some free living protozoa, *Ochromonas malhamensis*, *Euglena gracilis*, and *Tetrahymena pyriformis* in vitro. Biotoxic effects have been found in experiments with *Amoeba proteus* and *Paramecium caudatum* (Nigrelli and Jakowska 1960). Before Sen and Lin (1975), no work had been reported on the effect of holothurin on *Trypanosoma duttoni* infection in Swiss Webster male mice.

The purpose of this study was to investigate the effect of holothurin on the natural defense mechanisms of the mice against *T. duttoni*.

## Methods and Materials

The strain of *Trypanosoma duttoni* used in this study has been passed at weekly intervals in Swiss Webster male mice (Camm-Research Laboratory, N. J.) by the intraperitoneal infection of infected blood washed in 1 percent sodium oxalate (1 gm/100 ml of physiologic saline) solution. In each group, 6 six-week old male mice were used (Experiment I), and 16 mice were distributed in 4 groups (Experiment II). The mice were fed 'Purina Laboratory Chow®' and water ad libitum. They were housed under standard laboratory conditions.

Mice were inoculated with trypanosomes from a donor mouse with a seven-day-old infection. Blood was obtained from infected animals by cardiac punc-

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ture using a 5 ml syringe equipped with a 24G-1 needle containing 2.5 ml of 1 percent oxalated 0.15 M saline solution. Oxalated blood was centrifuged (200 g) for 15 minutes, parasites separated from the plasma, washed with saline, resuspended, and counted with a hemocytometer. Toisson's fluid was employed as diluent. Dilutions were then made with 0.15 M NaCl solution until the desired concentrations of trypanosomes were obtained for animal inoculation.

A standard solution of holothurin (obtained from Dr. George D. Ruggieri, Director of Osborn Laboratories of Marine Sciences, Brooklyn, New York) was prepared by the method of Styles (1970). This was the crude holothurin, the first steroid saponin of animal origin, from which holothurin 'A' was obtained. The final concentration was equivalent to 0.9 mg/ml. Forty animals in four groups were employed for this investigation. The protocol consists of (1) a single dose of 0.18 mg of holothurin administered simultaneously with a standard inoculum of  $5 \times 10^4$  trypanosomes per mouse, (2) two 0.09 mg doses of holothurin administered on Days 3 and 4 prior to inoculation of  $5 \times 10^4$  trypanosomes, (3) two 0.09 mg doses of holothurin administered on Days 3 and 4 after infecting the mice with standard inoculum of trypanosome cells, and (4) normal mice infected with  $5 \times 10^4$  trypanosomes.

Parasitemias in representative experimentally infected hosts were followed by estimation of trypanosomal cell population in tail blood by duplicate hemocytometer counts at varying periods. All parasitemias (Tables 1, 2) are expressed as average hemocytometer counts. A factor of 2,000 applied to these data will convert all estimations in terms of cells/mm<sup>3</sup> of blood. Since all counts were made in like manner, comparison may be made from the hemocytometer estimations.

The data were studied as averages calculated from both experiments. Statistical treatment of the data was limited to expression of standard deviations and application of Students' t-test for significance of differences of means having a probability level of five percent or lower.

## Results

*Holothurin administration prior to inoculation of trypanosomes*—Mice received 0.09 mg of holothurin, in two equal doses, on Days 3 and 4 prior to inoculation of  $5 \times 10^4$  trypanosomes. In one experiment (I) the experimental mice had an average of  $22.4 \times 10^3$  organisms/mm<sup>3</sup> of blood at the peak of the parasitemia compared to an average of  $46.4 \times 10^3$  cells/mm<sup>3</sup> of blood in the controls. In the other experiment (II) the experimental animals had an average of  $21.6 \times 10^3$  trypanosomes/mm<sup>3</sup> of blood at the peak of the parasitemia compared to an average of  $67.4 \times 10^3$  organisms/mm<sup>3</sup> of blood in the controls.

*Holothurin administered simultaneously with trypanosomes*—The simultaneous administration of 0.18 mg of holothurin and  $5 \times 10^4$  trypanosomes also affected the level of parasitemia at the peak of the parasitemic period and throughout the course of the infection. In one experiment (I) the animals that had received both holothurin and trypanosome cells had

TABLE 1  
Average hemocytometer (S D) estimations of trypanosome populations in tail blood of mice treated with holothurin. (If the reader wishes, apply a factor of 2,000 to convert all data to numbers of cells/mm<sup>3</sup> of blood),  
Experiment I

Day	Prior	Simultaneous	After	Control
6	<1	2.8 ± 3.1	5.3 ± 5.9	5.2 ± 5.9
8	3.7 ± 5.5	5.5 ± 6.0	20.7 ± 5.4*	10.7 ± 10.7
10	5.8 ± 10.4	12.3 ± 12.5	37.0 ± 18.4*	19.7 ± 13.9
12	11.2 ± 24.0	11.5 ± 8.1	32.5 ± 8.3	23.2 ± 12.0
14	5.5 ± 12.0	7.5 ± 9.1	26.8 ± 10.7**	11.3 ± 7.1
16	3.8 ± 9.4	4.2 ± 6.5	7.8 ± 11.8	10.2 ± 9.4
18	<1	1.3 ± 3.3	<1	5.8 ± 9.9

\* Significance at 10% level of significance

\*\* Significance at 5% level of significance

an average of  $24.6 \times 10^3$  trypanosomes/mm<sup>3</sup> of blood, compared to an average of  $46.4 \times 10^3$  trypanosomes/mm<sup>3</sup> of blood at the peak of parasitemia in the controls. In the other experiment (II) the mice that had received both holothurin and trypanosome cells had an average of  $18.6 \times 10^3$  organisms/mm<sup>3</sup> of blood, compared to an average of  $67.4 \times 10^3$  organisms/mm<sup>3</sup> of blood at the peak of parasitemia in the controls.

*Holothurin administered after inoculation of trypanosomes*—Mice were inoculated with  $5 \times 10^4$  trypanosomes. On Days 3 and 4 after inoculation they were injected intraperitoneally with a total of 0.18 mg of holothurin. In one experiment (I) the experimental mice receiving holothurin had an average of  $74.0 \times 10^3$  trypanosomes/mm<sup>3</sup> of blood, compared to an average of  $46.4 \times 10^3$  trypanosomes/mm<sup>3</sup> of blood in the controls. In the other experiment (II) the experimental mice receiving holothurin had an average of  $241.0 \times 10^3$  organisms/mm<sup>3</sup> of blood, compared to an average of  $67.4 \times 10^3$  organisms/mm<sup>3</sup> of blood in the control counterpart.

The parasitemias in four groups in one experiment (I) showed differences in parasite numbers, but these differences were not significant at the five percent level of significance on most days of experimentation (Table 1). The parasitemias in four groups in the other experiment (II) were found to be significantly different at the five percent level of significance on most days of experimentation (Table 2).

TABLE 2  
Average hemocytometer (S D) estimations of trypanosome populations in tail blood of mice treated with holothurin, Experiment II

Day	Prior	Simultaneous	After	Control
6	5.5 ± 9.1	<1	33.0 ± 7.1**	4.5 ± 1.6
8	4.3 ± 4.6*	7.0 ± 2.0*	71.5 ± 4.9**	19.7 ± 10.4
10	10.8 ± 11.6*	4.8 ± 5.6**	74.5 ± 50.2	30.2 ± 9.4
12	10.5 ± 8.9*	8.3 ± 6.2**	120.5 ± 105.5	33.7 ± 14.4
14	4.8 ± 4.6*	8.5 ± 3.1*	77.0 ± 3.2	25.8 ± 16.5
16	<1	9.3 ± 5.6	44.0 ± 3.0**	<1
18	<1	<1	<1	<1

\* Significance at 5% level of significance

\*\* Significance at 1% level of significance



### Discussion

Rats respond to *Trypanosoma lewisi* infection by producing ablasic antibody as well as other anti-trypanosome antibodies. Ablastic antibody, called ablacin by Taliaferro (1932), inhibits trypanosome division but does not agglutinate or lyse the trypanosomes. Ablacin is probably an IgG immunoglobulin (D'Alesandro 1959) which is differentiated from the other anti-trypanosome antibodies by its apparent low avidity for the trypanosomes (D'Alesandro 1970). Like the other anti-trypanosome antibodies, ablacin is undetectable in normal rats and increases in titer during the infection (Coventry 1930), its activity in immune rat serum is transferable to normal rats (Taliaferro 1932), and it functions in vitro (D'Alesandro 1962).

Taliaferro and Pavlinova (1936) found that the general course of *Trypanosoma duttoni* (= *musculi*) infections in mice are similar to *T. lewisi* in the rat. The reproduction of *T. duttoni* is not as marked in the population of parasites in the peripheral blood of mice and the inhibition of reproduction of the parasites are not as pronounced as during *T. lewisi* infection in the rat. Even though ablacin (antibody) and ablacinogen (antigen) are demonstrable and particularly characterized, the localization of ablacinogen, and thus the site of ablacin's action, are still unknown (Bawden 1975). Patton (1975) is of the opinion that though ablacin clearly interrupts the reproduction of *T. lewisi* the primary effect of ablacin is still a subject of speculation.

The results in the present investigation show that prior and simultaneous treatments of mice with holothurin increased their resistance to subsequent infection with *Trypanosoma duttoni*. This resistance was measured by the number of organisms at the peak and throughout the course of the infection. However, once parasitemia had developed, the injection of holothurin caused an enhancement of the infection when compared with the controls.

It is difficult to find a reasonable explanation for the observed effects unless at least two antagonistic influences, one inhibitory and the other enhancing, are ascribed to the holothurin (Styles 1970). There are several possible explanations that might account for the action of this marine biotoxin. One might speculate that the effect of holothurin (a poison of animal origin) is exerted directly on the trypanosomes as a toxic factor. It is interesting to note that this biotoxin has almost identical effects to those of bacterial endotoxins. Singer et al. (1964) found the resistance of mice was enhanced when endotoxin was administered prior to infection with *T. duttoni* and other trypanosomes. Styles (1970) reported that rats treated with holothurin prior to and simultaneously with an infection of *T. lewisi* had lower parasitemias than controls.

The other speculation is that holothurin may act by interfering with the transport of essential substances across the *T. duttoni* plasma membrane. Patton (1972) showed in vitro that ouabain inhibits the reproduction of *T. lewisi* and that the effect is indistinguishable from reproduction inhibition produced by ablacin in vitro. The mechanism by which holothurin is able to influence resistance against *Try-*

*panosoma duttoni* in mice is unknown, but it may have such action on the surface of the trypanosomes.

However, once parasitemia had developed, the injection of holothurin caused an enhancement of the infection when compared with the controls. A higher level of parasitemia was observed by Styles (1970) in rats treated with holothurin after infection with *T. lewisi*. Singer et al. (1964) injected bacterial endotoxin in mice 24 hours after infection with *T. duttoni*. They showed that the trypanosome infection had rendered the mice more susceptible to the effects of endotoxin or that during this period of the infection endotoxin was instrumental in precipitously obliterating the remaining natural resistance of the animals to the trypanosome so that death followed.

The course of *T. lewisi* infections was altered in favor of the parasite by treatment with the synthetic corticosteroid, dexamethasone (Patton and Clarke 1968). The growth of *T. duttoni* is known to be affected when its normal host is subjected to certain kinds of stress. Starvation, low temperature, multiple infections, intraspecies fighting, blockade of the Reticulo Endothelial System, etc. may alter the normally well-balanced host-parasite relationships in favor of the parasites (Krampitz 1975). These observations indicate that the immune response may be influenced by some hormonal and/or nutritional patterns. The mechanism by which holothurin (a steroid saponin of animal origin) is able to influence susceptibility of mice to trypanosome infection is not understood clearly, but it may be similar to endotoxin. One can further suggest that enhancement of the infection is the result of interference with the formation of adequate antibody once parasitemia has developed.

No matter what the mechanism, the previously untested experimental models (*Trypanosoma duttoni* and Swiss Webster male mice) presented here should yield further information on the action of holothurin and on the nonspecific factor of resistance to trypanosomiasis. It is hoped that further studies will help to elucidate the mechanisms involved.

### Literature Cited

- Bawden, M. P. 1975. Whence comes *Trypanosoma lewisi* antigen which induces ablasic antibody: Studies in the occult? *Exp. Parasitol.* **38**:350-356.
- Coventry, F. A. 1930. The trypanocidal action of specific antisera on *Trypanosoma lewisi* in vivo. *Am. J. Hyg.* **12**:366-380.
- D'Alesandro, P. A. 1959. Electrophoretic and ultracentrifugal studies on antibodies to *Trypanosoma lewisi*. *J. Infect. Dis.* **105**:76-95.
- D'Alesandro, P. A. 1962. In vitro studies of ablacin, the reproduction inhibiting antibody to *Trypanosoma lewisi*. *J. Protozool.* **9**:351-358.
- D'Alesandro, P. A. 1970. Nonpathogenic trypanosomes of rodents, in "immunity to parasitic animals" (Jackson, G. J., R. Herman., and I. Singer, eds.), Vol 2., pp. 691-738. Appleton-Century-Crofts, New York.
- Dusanic, D. G. 1975. Immunosuppression and ablacin. *Exp. Parasitol.* **38**:322-337.
- Krampitz, H. E. 1975. Ablacin: Antigenic Tolerance and lack of ablacin control of *Trypanosoma musculi* during host's pregnancy. *Exp. Parasitol.* **38**:317-321.
- Lincicome, D. R., and J. Shepperson. 1963. Increased rate of growth of mice infected with *Trypanosoma duttoni*. *J. Parasitol.* **49**:31-34.



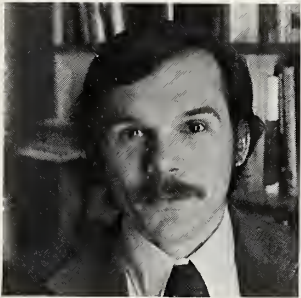
- Lincicome, D. R., D. K. Sen., and B. Combosus. 1965. Development of *Trypanosoma duttoni*. J. Parasitol. 51:(No. 2., Sec. 2) 27.
- Nigrelli, R. F., and S. Jakowska. 1960. Effects of holothurin a steroid saponin from Bahamian sea cucumber (*Actinopyga agassiz*) on various biological systems. Ann. N. Y. Acad. Sci. 90:884-892.
- Patton, C. L. 1972. Inhibition of reproduction in *Trypanosoma lewisi* by ouabain. Nature New Biol. 237:253-255.
- Patton, C. L. 1975. The ablastin phenomenon: Inhibition of membrane function. Exp. Parasitol. 38:357-369.
- Patton, C. L., and D. T. Clarke. 1968. *Trypanosoma lewisi* infections in normal rats and rats treated with dexamethasone. J. Protozool. 15:31-35.
- Sen, D. K., and V. K. Lin. 1975. Effect of holothurin on *Trypanosoma duttoni* in Swiss Webster male mice. J. Protozool. 22:25-26A.
- Singer, I., E. T. Kimble, and R. E. Ritts, Jr. 1964. Alterations of the host-parasite relationship by administration of endotoxin to mice with infections of trypanosomes. J. Inf. Dis. 114:243-248.
- Styles, T. J. 1970. Effect of holothurin on *Trypanosoma lewisi* infections in rats. J. Protozool. 17:196-198.
- Taliaferro, W. H. 1932. Trypanocidal and reproduction-inhibiting antibodies to *Trypanosoma lewisi* in rats and rabbits. Am. J. Hyg. 16:32-84.
- Taliaferro, W. H., and Y. Pavlinova. 1936. The course of infection of *Trypanosoma duttoni* in normal, splenectomized and blockaded mice. J. Parasitol. 22:29-41.
- Targett, G. A. T., and P. Viens. 1975. Ablastin: Control of *Trypanosoma musculi* infections in mice. Exp. Parasitol. 38:309-316.

# The Vibration Correlates of Ride Quality of Buses<sup>1</sup>

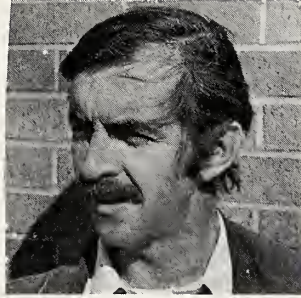
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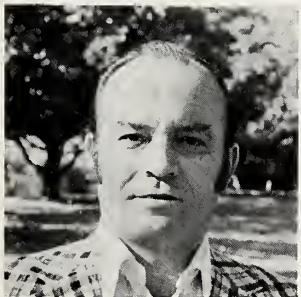
(Received, Jan. 9, 1977 Revised, Mar. 2, 1977)



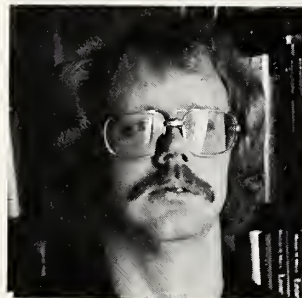
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Photo not Available

**Abstract**— The present research was conducted to evaluate the various vibration components of a bus ride and their relationship to ratings of ride quality. Three rating scales were used to assess ride comfort. Four bus tests were run with a different subject population for each test. The results suggest that energy levels were moderately correlated with comfort ratings. There was no evidence that any single vibration band, axis, or combination of these factors was a better determinant of comfort ratings than total energy. The modest relationship found in the present study suggests that factors other than vibration may be more important determinants of ride quality.

## Introduction

Since the pioneering work of Jacklin and Liddell (1933) on the effects of vibration on subjective ratings of comfort, numerous laboratory and field studies have been conducted to evaluate the effects of various types of vibratory stimuli on ride quality ratings (see the literature reviews of Guignard and King 1972 and Jacobson 1972). Field tests have considered ride quality ratings for an entire trip (e.g., Kuhlthau and Jacobson 1973; Manenica and Corlett 1973; Nos-

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kowitz and Jacobson 1974; Osborne and Clarke 1973) and for specific aspects of a trip, such as deceleration, jerk, or lateral forces produced by turning (e.g., Urabe and Nomura 1964; Gebhard 1970; Healey, Stearman and Smith 1974). There have been relatively few, if any, studies using field tests to identify which parameters of the vibratory stimulus (frequency range, amplitude, or axis of motion) might be more important in determining the passenger's evaluation of ride quality.

The purposes of the present research were (1) to more completely describe the vibratory stimuli produced by transit buses and (2) to determine the relationship between passenger ratings of ride quality on these buses with the various parameters of vibration derived from measurements taken on the buses. Thus, the present research attempted to isolate those characteristics of vibration associated with ratings of ride quality and therefore provide direction for future experimental analysis of vehicle comfort ratings.

### Method

**Research Plan**—The research plan employed exposed subject-passengers to actual ride environments on buses. These passengers were asked to make ratings of comfort for a variety of road conditions and vehicle speeds. Seventeen 15-second test segments were selected to sample a range of ride environments during a 1 hour and 45 minute trip. Four bus tests were conducted over the same route. The rating scale employed on the first test ride was a five-point scale. On the second ride a magnitude estimation scale was used, while on the last two rides a six-point rating scale was used.

**Subjects**—The subjects for the ride using the 5-point category-estimation procedure were 26 undergraduate students recruited from the student body of Old Dominion University. The mean age was 22.8 years, and the standard deviation was 6.2 years. For the ride using the magnitude estimation procedure, 20 subjects were used, 8 of whom were recruited from the student body of Old Dominion University and 12 who had never attended college. The mean age of these subjects was 18.5 years with a standard deviation of 2.6 years. For the first ride using the 6-point category-estimation procedure 17 subjects were used, 7 of whom were recruited from the student body of Old Dominion University and the remaining 10 who had never attended college. The mean age of this group was 18.9 years with a standard deviation of 3.7 years. The second ride using the 6-point procedure used 26 college students, recruited from Old Dominion University; the mean age was 23.8 years, and the standard deviation was 6.2 years.

**Apparatus**—A Virginia Transit Company bus and an experienced driver were leased for each of the test rides. Each bus was equipped with 39 seats. The passenger-subjects were only permitted to sit on the 31 seats that faced toward the front of the bus. Vibration was measured with a Langley Research Center Ride Measurement Package (Catherines, Clevenson, and Scholl 1972) that was located at a forward position on the bus floor. This instrument utilized servo accelerometers and recorded on magnetic tape the vibrations in each of the three linear axes. No angular

accelerations were measured. The subjects were provided with clipboards and rating forms on which to record their responses.

**Procedure**—Prior to boarding the bus, the subjects were taken to a classroom and given their instructions regarding the procedures to be employed, including the use of the rating scale used on that ride. Only the core of the instructions given the subjects are included here. Those subjects who were to use the five-point category estimation procedure were told:

"For each of the 17 ride segments, you will be given a verbal signal to rate the ride quality of the particular segment. For each segment, you may rate the ride quality *excellent* by placing a number '5' in the proper blank, *good*, by placing a '4' in the blank, *fair*, by using a '3', *poor*, by marking with a '2', or *unacceptable*, by placing a number '1' in the blank. You will make 17 ratings; each will be rated with either a 1, 2, 3, 4, or 5. Remember, you are rating the ride quality of each ride segment. Are there any questions concerning this rating scale?"

The subjects who were to use the magnitude estimation procedure were told:

"For each of the 17 ride segments, you will be given a verbal signal to rate the ride quality of the particular segment. The first ride segment may be rated with any number you wish. This rating and all additional ratings will be your guide for any ratings which follow. That is, if the second ride segment has a better ride quality than the first, it will receive a higher rating. If it has a poorer ride quality than the first, it will receive a lower rating. If the ride quality of the two segments are the same, they will receive the same rating. You will make 17 ratings; each will be rated with a number (your choice) along a continuum with the highest number corresponding to the best ride quality and the lowest number corresponding to the poorest ride quality. Remember, you are rating the ride quality of each ride segment. Are there any questions concerning this rating scale?"

The subjects who were to use the six-category estimation procedure were told:

"For each of the 17 ride segments you will be given a verbal signal to rate the quality of that particular segment. If the quality of the ride is satisfactory to you, place a '6' in the blank if it is *very satisfactory*, a '5' if it is *moderately satisfactory*, or a '4' if it is *mildly satisfactory*. If the quality of the ride is not satisfactory to you, place a '3' in the blank if it is *mildly unsatisfactory*, a '2' if it is *moderately unsatisfactory*, or '1' if it is *very unsatisfactory*. You will make 17 ratings; each will be rated with either a 1, 2, 3, 4, 5, or 6. Remember, you are rating the ride quality of each ride segment. Are there any questions concerning this rating scale?"

The subjects were allowed to talk or read between test segments but not during them, and they were instructed not to move from one seat to another. Finally, they were asked not to discuss their ratings with the other subjects on the bus.

The route chosen for the rides covered 50 miles and was selected to include a wide variety of the prevailing road conditions found in the Norfolk-Virginia

TABLE 1  
Total average power (TAP) of vibrational stimuli

	Ride/Scale	Axis	1-3	3-5	5-7	7-9	9-11	11-13	13-15	15-17	17-19	19-21	21-23	23-25
Mean	1/Five-Point	V	4.11	.49	.94	1.73	3.50	5.01	12.70	1.11	1.00	.84	.60	.21
		L	.05	.19	.38	1.21	4.28	5.08	10.99	2.86	1.90	2.12	1.41	.80
		LAT	.06	.12	.20	.55	3.74	8.07	22.61	2.42	.57	.51	.42	.24
	2/Mag. Est.	V	5.33	.61	.82	1.74	3.31	4.18	12.71	.91	.94	.94	.62	.17
		L	.05	.16	.19	.48	1.50	1.03	1.95	.42	.40	.42	.21	.10
		LAT	.08	.12	.19	.38	3.17	5.01	14.57	1.57	.27	.19	.11	.07
	3/Six-Point	V	2.46	.68	.99	1.39	3.06	2.33	1.57	.61	.90	.76	.50	.23
		L	.03	.16	.37	.59	3.28	2.41	1.48	.43	.51	.76	.48	.34
		LAT	.10	.27	.52	.32	1.88	4.52	6.60	.68	.22	.19	.17	.11
	4/Six-Point	V	4.09	.58	.93	2.07	2.54	4.09	5.84	.76	.82	.86	.67	.17
		L	.04	.18	.24	.59	1.86	2.89	4.90	2.55	2.28	2.52	1.57	.82
		LAT	.07	.29	.66	.54	2.36	6.27	14.60	2.99	.90	.91	.54	.35
Standard Deviation	1/Five-Point	V	2.56	.29	.59	1.43	3.56	4.56	13.54	.76	.59	.64	.45	.18
		L	.05	.14	.30	1.62	4.32	4.39	16.30	2.69	1.91	2.16	1.21	.64
		LAT	.04	.14	.23	.64	5.08	8.89	24.96	2.20	.53	.52	.36	.23
	2/Mag. Est.	V	6.27	.45	.62	1.30	3.09	3.01	13.55	.52	.55	.63	.46	.11
		L	.07	.14	.18	.36	1.18	.62	1.69	.29	.30	.34	.15	.07
		LAT	.06	.11	.21	.48	3.71	4.89	13.80	.98	.19	.15	.09	.13
	3/Six-Point	V	2.42	.81	.81	1.12	2.80	1.56	1.22	.50	.74	.67	.50	.20
		L	.04	.53	.66	.54	3.00	2.29	1.02	.34	.44	.74	.49	.37
		LAT	.57	.33	.51	.55	2.30	4.74	4.61	.49	.17	.19	.18	.09
	4/Six-Point	V	3.47	.53	.67	1.44	2.05	2.63	4.94	.35	.41	.43	.41	.09
		L	.05	.14	.14	.54	1.44	2.39	4.28	2.95	2.90	1.89	1.25	.57
		LAT	.05	.33	.62	.46	2.47	5.40	14.75	1.94	1.19	1.19	.66	.30

Beach, Virginia area. Each of the 17 segments of the ride selected for evaluation lasted 15 seconds and was separated from each other segment by approximately 5 to 10 minutes. These segments were selected to sample the varying road conditions and because of the availability of landmarks that could be easily identified by the experimenters. Prior to traversing each test segment the bus driver was instructed to maintain a constant and specified speed. The subjects were alerted 10 seconds before reaching each test segment and told when the segment began and ended. A loudspeaker was used to direct the subjects.

### Results and Discussion

The taped records of the vibrations recorded on the buses were analyzed by the Langley Research Center Time Series Analysis Program which generated the power spectra associated with each axis in each vibration segment. The resultant power spectra were then utilized in a subroutine to calculate the total average power (TAP) level in 2 Hz bandwidths in the range of 1 to 25 Hz. Thus, 36 vibration parameters were derived for each ride segment consisting of the TAP for each of the 12 frequency bands in each of the 3 linear axes of vibration—vertical (up and down), lateral (side-to-side), and longitudinal (fore and aft).

The TAP data are shown in Table 1. This presents the means and standard deviations of the accelerations recorded, averaged across the 17 ride segments, for each of the frequency bands in each of the 3 axes of linear vibration for each test ride. Generally, the greatest amount of energy recorded was in the 13-15 Hz band with the energy distributed rather evenly about the 13-15 Hz band except for a secondary energy peak in the lowest band of the vertical axis. There are some notable exceptions to this pattern, especially in the lateral axis and on the third test ride.

In fact, there is sufficient variation in the vibration recorded from ride to ride to make comparison of the subjective evaluations across the various rides of questionable value.

A factor analysis using the 36 physical vibration measurements from each of the 17 segments on all 4 rides ( $17 \times 4$  observations) was performed in an attempt to identify groups of frequencies, axes, or combinations of these that were varying together and therefore may have acted together to affect the ratings. The factor analysis was computed using the SPSS program for factor analysis with VARIMAX rotation; the default criterion of minimum eigenvalue (i.e., 1.0) was used for determining the number of factors to be extracted. The results of this analysis are shown in Table 2. This analysis yielded 5 significant factors, and the table presents the factor loadings for each of the 36 measures on these factors. The first factor was identified as a general factor consisting primarily of the effects from the frequencies below 11 Hz, but excluding vertical vibration below 3 Hz. Also, this factor included effects from frequencies above 17 Hz in the vertical and lateral axes. The variables excluded from the first factor are the middle frequencies between 11 and 17 Hz. The second factor was identified as a *high frequency longitudinal factor* and loaded mostly in the longitudinal axis above 7 Hz. The third factor was defined by frequencies above 7 Hz in both the vertical and lateral axes, and has been identified tentatively as a *high frequency vertical-lateral factor*, although some of these higher frequencies also contributed to the first factor as well. The fourth factor was specific to the energy produced by the 13-15 Hz bands from all 3 axes. The last factor was also a specific factor defined by the vertical axis below 7 Hz.

Simply, in addition to a general level of vibration which involved all of the axes and most of the fre-



quencies, there were four other patterns of vibration apparent in the bus-ride physical measures: (1) middle and high frequency longitudinal vibration, (2) middle and high frequency vibration in the other two axes, (3) vibration in all 3 axes between 13 and 15 Hz, and (4) low frequency vertical vibration.

*The Subjective Ratings*—Table 3 presents the means of simple correlations (Pearson *r*) between each individual's ratings and the 36 parameters of vibration for each ride. This table also presents the means of these correlations (next to the last column) and the means of the individual correlations between each subject's ratings and the total vibration energy recorded for each of the 17 segments of the ride (last column). Although some of the correlation coefficients obtained for the five-point procedure are moderately high, the correlations for the other procedures are rather low. Included among these rather low correlations are those between the subjective ratings and the total energy recorded at each test segment.

Regression analyses were used, in a second analysis of the relationship between the vibration parameters and the subjective ratings, to determine the multiple correlations between these two sets of measures. Analyses were performed on each ride separately. This is probably the most appropriate measure of their correlation. Further, these analyses are potentially useful in suggesting the relative importance of combinations of axes and frequency bands for the prediction of subjective ratings. The data used for the predictor variables in these regression analyses were the 36 parameters of vibration, while the criterion variable chosen was the individual subject's rating of each test segment. An alternative criterion variable that has been frequently used is to employ the mean rating for a given group of subjects. This would most likely have resulted in higher multiple correlation coefficients, as well as higher simple correlations with the physical measures of vibration. However, the individual rating was chosen because it is this measure to which a predictive equation for ride comfort should ultimately be applied and not to the mean rating of a group of individuals.

The multiple correlation coefficients yielded by the multiple regression analyses are shown in Table 4. The first column presents the predictor variables, and the second column presents the multiple correlation coefficient based on the given predictor variable plus

TABLE 2  
*Factor analysis for physical vibration measurements*

Frequency	Axis	1	2	3	4	5	Communality
1-3	V	.07	.01	.08	.02	.75	.57
	L	.76	-.03	.01	.00	.23	.64
	LAT	.91	.07	.27	.19	.07	.95
3-5	V	.51	.14	.17	.09	.75	.88
	L	.67	.03	-.05	-.15	.10	.49
	LAT	.88	.13	.20	.05	.21	.88
5-7	V	.53	.27	.20	.08	.52	.67
	L	.67	.05	.23	.40	.00	.66
	LAT	.81	.08	.25	.23	.03	.79
7-9	V	.76	.32	.25	.13	.21	.81
	L	.73	.30	.13	.27	.14	.73
	LAT	.80	.11	.36	.10	.05	.79
9-11	V	.81	.21	.46	.05	.14	.94
	L	.71	.49	.22	.04	.20	.83
	LAT	.62	.33	.49	-.01	.09	.75
11-13	V	.44	.02	.78	.14	.07	.82
	L	.11	.66	.14	.26	.40	.69
	LAT	.47	.45	.63	.10	.12	.84
13-15	V	.45	.09	.38	.72	.04	.87
	L	.00	.43	.01	.69	.15	.68
	LAT	.50	.15	.51	.58	.01	.87
15-17	V	.36	.03	.86	.15	.24	.94
	L	.07	.87	.16	.14	.14	.82
	LAT	.08	-.07	.81	.06	.11	.68
17-19	V	.71	.27	.49	.16	.23	.89
	L	-.05	.94	.05	-.03	.07	.89
	LAT	.55	.39	.47	.18	-.03	.71
19-21	V	.82	.26	.38	.21	.06	.93
	L	.09	.88	-.05	-.01	-.06	.78
	LAT	.38	.66	.51	.09	-.01	.84
21-23	V	.64	.49	.29	.17	.27	.84
	L	.29	.86	.01	.17	.00	.85
	LAT	.56	.55	.53	.11	-.04	.91
23-25	V	.83	.19	.40	.24	.02	.94
	L	.34	.80	-.02	.14	.00	.77
	LAT	.71	.34	.49	.18	-.07	.89

the predictor variables listed above it. For comparison purposes, the simple correlation between the given predictor variable and the criterion measure is presented in the third column. It should be noted that these analyses were done in a step-wise fashion, so that the predictor variables are ordered by the amount of additional variability in the ratings accounted for by that predictor variable. Thus, the first variable listed accounts for the most variability in

TABLE 3  
*Individual correlations between vibration and quality ratings*

Scale	Axis	1-3	3-5	5-7	7-9	9-11	11-13	13-15	15-17	17-19	19-21	21-23	23-25	Mean	Total
Five-point	V	.10	.32	.52	.51	.48	.52	-.09	.43	.55	.52	.51	.50	.41	.35
	L	.09	.05	.03	.33	.56	.25	.01	.39	.47	.46	.48	.38	.29	
	LAT	.40	.39	.38	.45	.45	.50	.03	.27	.46	.47	.47	.49	.40	
Mag. Est.	V	.26	.30	.37	.31	.39	.36	.02	.40	.40	.36	.40	.34	.33	.31
	L	.07	-.06	.03	.20	.41	.44	.05	.37	.35	.27	.36	.32	.16	
	LAT	.14	.29	.22	.20	.32	.32	.05	.30	.31	.34	.37	.12	.25	
Six-point	V	.11	.09	.14	.31	.32	.29	.18	.25	.29	.29	.28	.30	.24	.30
	L	-.06	-.05	-.12	.23	.33	.29	.07	.31	.32	.33	.30	.30	.19	
	LAT	-.06	.14	-.01	.19	.30	.32	.14	.27	.33	.30	.29	.34	.21	
Six-point	V	.20	.28	.28	.22	.26	.20	.03	.17	.22	.22	.21	.26	.21	.30
	L	.14	.06	.05	.20	.17	.26	.06	.16	.12	-.01	.10	.06	.11	
	LAT	.24	.28	.09	.24	.16	.19	-.02	.04	.12	.10	.11	.00	.13	

TABLE 4  
Multiple regression analyses

Five-point			Mag. Est.			Six-point			Six-point		
Var.	Mult. r	Simp. r	Var.	Mult. r	Simp. r	Var.	Mult. r	Simp. r	Var.	Mult. r	Simp. r
L			L			Lat			Lat		
9-11	.56	.56	11-13	.44	.44	23-25	.34	.34	3-5	.28	.28
V			L			Lat			L		
7-9	.57	.51	5-7	.45	.03	17-19	.35	.33	11-13	.31	.26
V			V			V			L		
1-3	.58	.10	13-15	.46	.02	3-5	.35	.09	19-21	.32	.01
L			Lat			V			Lat		
21-23	.59	.48	3-5	.48	.29	9-11	.36	.32	13-15	.33	-.02
L			L			Lat			Lat		
13-15	.60	.01	19-21	.48	.27	5-7	.36	-.01	23-25	.34	.003
L			V			L			Lat		
1-3	.61	.09	7-9	.49	.31	9-11	.37	.33	9-11	.35	.16
V			L			Lat			V		
9-11	.61	.48	15-17	.49	.37	13-15	.37	.14	5-7	.37	.27
V			L			V			L		
13-15	.61	-.09	21-23	.50	.36	5-7	.37	.14	21-23	.38	.11
L			V			L			Lat		
11-13	.61	.25	15-17	.50	.30	13-15	.38	.07	1-3	.38	.23
V			Lat			V			Lat		
23-25	.61	.50	15-17	.50	.30	17-19	.38	.29	7-9	.38	.23
L			Lat			Lat			V		
3-5	.61	.05	9-11	.50	.32	7-9	.38	.19	7-9	.39	.22
V						L			V		
3-5	.61	.32				3-5	.38	-.05	11-13	.39	.21
Lat						L					
1-3	.61	.40				5-7	.38	-.12			
V						L					
19-21	.61	.52				15-17	.38	.31			
L											
17-19	.61	.47									

ratings, while the second predictor variable listed accounts for more of the remaining variability in the ratings than any of the remaining predictor variables, etc. In this technique, variables continue to be listed only as long as they produce a specified increase in the multiple correlation coefficient.

The most pertinent features of the regression analyses are the sizes of the multiple correlation coefficients and the ordering of the variables. In none of the analyses was the size of the multiple correlation appreciably increased over that of the highest simple correlation, that of the first predictor variable. Since the regression analyses account for so little additional variance in the ratings of the subjects over that accounted for by the highest simple correlation, the failure to find a consistent pattern in the ordering of the predictor variables across rides is not surprising. The present analyses failed to yield a consistent pattern across the rides, with respect to either axis or frequency. None of the 36 predictor variables appeared in all 4 analyses and only 3 appeared in 3 of the 4 analyses. It was assumed at the onset that if any axis or frequency of vibration was particularly important to the subjective evaluation of ride quality that this would be revealed in some consistent pattern among the regression analyses. It is possible that the absence of a pattern is due to differences across the 4 test rides in the amount and variability of energy found in the 36 physical parameters. The elimination

of this interride variability may have permitted a pattern to have been revealed. The same point may be made with respect to the use of different rating procedures across the different tests. At present, however, all that can be concluded is that the regression analyses do not reveal any combination of frequencies or axes that are singularly important to ride quality ratings, nor an appreciable increase in the level of correlation found with the simple correlations (Table 3).

In summary, the results of these analyses suggest that a moderate relationship exists between the amount of vibration present on buses and the subjective ratings of ride quality, with the ride on which the five-point scalar technique was used providing the clearest indication of this relationship. Although the quality ratings declined with increasing energy levels, this pattern was not strong. Since it is well established that both frequency and amplitude of vibration affect ratings of ride quality (e.g., Jacklin and Liddell 1933), the question remains as to why there was only moderate support for this finding in the present research. A possible reason for the observed findings might be that the ride segments used were subjectively homogeneous, despite the attempt to choose the most disparate ride environments available. Another possibility is that the primary determinant of ride comfort ratings, given the vibration energy levels encountered in this research, is not vibration. It may also be the



case that the vibration levels typically found on buses are relatively unimportant as predictors of ride quality due to the presence of other more potent factors. These factors may range from environmental factors (i.e., scenery, temperature, odors) to the characteristics of the passenger (i.e., attention, mood, age, and health) and, perhaps most importantly, the availability to the passenger of convenient and economical alternatives to the bus. The determination of the potential relevance of these factors and other variables must await empirical resolution.

### Literature Cited

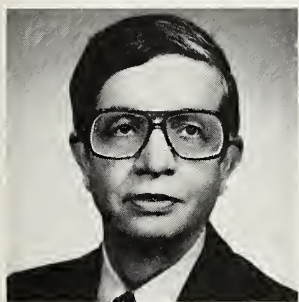
- Catherines, J. J., S. A. Clevenson, and H. F. Scholl. 1972. A method for the measurement and analysis for ride vibrations of transportation systems. NASA TN D-6785.
- Gebhard, J. W. 1970. Acceleration and comfort in public ground transportation. Transportation Programs Report-002, Applied Physics Laboratory, Johns Hopkins University, February, 1970.
- Guignard, J. C., and P. F. King. 1972. Aeromedical aspects of vibration and noise. AGARD-Monograph No. 151, North Atlantic Treaty Organization.
- Healy, A. J., R. O. Stearman, and C. C. Smith. 1974. Automobile riding quality with real highway roughness. AIAA Paper No. 74-1301. Presented at the AIAA Life Sciences and Systems Conference, November, 1974.
- Jacklin, H. M., and G. J. Liddell. 1933. Ride comfort analysis. Research Bulletin No. 44, Engineering Experiment Station, Purdue University, May 1933.
- Jacobson, I. D. 1972. Criteria for ride quality-motion. STOL Program Memorandum Report 40302, University of Virginia.
- Kuhlthau, A. R., and I. D. Jacobson. 1973. Analysis of passenger acceptance of commercial flights having characteristics similar to STOL. STOL Program Technical Report 403208. Paper presented at the Flight Test Symposium, Ottawa, Canada, March 7-8, 1973.
- Manenica, I. and E. N. Corlett. 1973. A model of vehicle comfort and a method for its assessment. *Ergonomics*, **16**:849-854.
- Noskowitz, D., and I. D. Jacobson. 1974. Passenger demographic and subjective response to commuter aircraft in the northeast. Memorandum Report 403219, Short-haul Air Transportation Program, University of Virginia, December 1974.
- Osborne, D. J. and M. J. Clarke. 1973. The development of questionnaire surveys for the investigation of passenger comfort. *Ergonomics*, **16**:855-869.
- Urabe, S., and Y. Nomura. 1964. Evaluation of train riding comfort under various decelerations. Quarterly Report of the Railway Technology Research Institute, Japanese National Railways, June 1964, 28-34.

# Neutron Reaction Cross Sections in Si and Fe at 14.5 Mev

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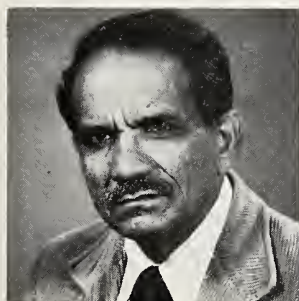
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## Introduction

In recent years, (n, p) and (n,  $\alpha$ ) reactions at an incident neutron energy of 14.5 MeV have been used to obtain information about the relative abundances of different elements in various types of soils, minerals, meteorites, and lunar samples. This technique is quite reliable if the relevant reaction cross sections are known with sufficient accuracy. Comparisons of lunar soil and rock composition data with meteoritic and terrestrial crust values have shown that lunar samples have certain characteristics uniquely related to their histories. The precise chemical composition of lunar and other extraterrestrial samples thus assumes a particular significance in cosmological studies.

We have examined the literature for reported values of neutron reaction cross sections at 14.5 MeV for the predominant elements in lunar and terrestrial soils. This examination revealed that (n, x) cross sections at 14.5 MeV for iron, silicon, and titanium are in a generally unsatisfactory state.

For example, the reported cross-sectional values for the  $^{28}\text{Si}(n,p)^{28}\text{Al}$  reaction range from  $160 \pm 16$  to  $355 \pm 40$  mb, while those for the  $^{56}\text{Fe}(n,p)^{56}\text{Mn}$  reaction range from  $72 \pm 7$  to  $144 \pm 19$  mb (Cuzzocrea and Perillo 1971). Silicon is the second most abundant constituent of soils of terrestrial origin. It is a major constituent of lunar soils and quite possibly soils of other planets. In addition, an accurate knowledge of Si(n,x) reaction cross sections has some bearing on neutron irradiation damage to silicon devices. Iron is the fourth most abundant element in the earth's crust. It also has a comparatively high abundance in lunar samples. Titanium is a relatively minor constituent of terrestrial crust samples. However, some lunar rocks have been found to have unusually high concentrations of titanium as compared with terrestrial and meteoritic samples.

In this paper, attention is focused on (n,p) and (n, $\alpha$ ) cross sections at 14.5 MeV for various isotopes of silicon and iron. Results of experimental cross-sectional measurements are presented and compared with theoretical values.

## Review of Cross Section Theory

Statistical model calculations of (n,p) and (n, $\alpha$ ) reaction cross sections for neutron energies in the 14 to 15 MeV range have not, in general, been very successful. As a result, there have been several attempts to develop empirical expressions for predict-

**Abstract**— Measured intensities of gamma rays have been used to determine experimental cross sections for (n, p) and (n,  $\alpha$ ) reactions induced by 14.5 MeV neutrons in various isotopes of silicon and iron. These cross sections are based on  $\sigma_{\text{na}}(^{27}\text{Al}) = 114 \pm 6$  mb for the monitor reaction. Results are compared with previously reported experimental and theoretical values.

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ing these cross sections. Levokovskii (1964, 1974), based on his own data and those reported in the literature, proposed the following equations for (n,p) cross sections:

$$\sigma(n, p) = [45.2(A^{1/3} + 1)^2] \quad (1)$$

$$\exp \left[ -33 \left( \frac{N - Z + 1}{A + 1} \right) \right] \text{mb}$$

for  $N \leq 20$  and

$$\sigma(n, p) = [45.2(A^{1/3} + 1)^2] \quad (2)$$

$$\exp \left[ -33 \left( \frac{N - Z}{A} \right) \right] \text{mb}$$

for  $N > 20$  where  $A$  is the atomic mass,  $Z$  is the atomic number, and  $N$  is the neutron number of the target nucleus. The agreement between the experimental values and the predictions of Levokovskii is generally good for atomic numbers in the range  $Z = 9 - 33$ . However, there are a number of elements, including Si and Fe, for which the empirical values of Levokovskii and the experimental results are in substantial disagreement and for which the experimental data are either badly scattered or meager.

Gardner et al. (1962, 1964, 1967) have been able to calculate (n, p) and (n,  $\alpha$ ) cross sections in good agreement with many observed values. Their approach was based on the statistical model of the nucleus and employed the semiempirical equation

$$\sigma(n, x) = \sigma_c(n) \sum_x \frac{F_x^*}{F_x} \quad (3)$$

where

$\sigma_c(n)$  = Cross section for formation of the compound nucleus

$F_x^*$  = Probability that only an  $x$  type particle (p or  $\alpha$ ) is emitted

$F_x$  = Probability that an  $x$  type particle is emitted whether or not it is followed by a second particle.

The functions  $F_x$  can be calculated from

$$F_x = \frac{2m_x}{h^2} \int_{U_x}^{E_m} E \sigma_c(E) \omega(E_m - E) dE \quad (4)$$

where

$E$  = Energy of the emitted  $x$  particle

$E_m = E_n + Q_{nx} - \delta$  = total excitation energy available for (n,  $x$ ) reaction

$E_n$  = Energy of the incident neutron

$Q_{nx}$  = Energy difference between the masses of initial and final particles for an (n,  $x$ ) reaction

$\delta$  = Pairing energy of the daughter nucleus

$\sigma_c(E)$  = Inverse cross section

$U_x$  = Effective coulomb barrier height for the  $x$  particle

$\omega(E_m - E)$  = Nuclear level density of the daughter nucleus

shell corrections other than that the pairing energy  $\delta$  is taken to be zero for odd-odd daughter nuclei and equal to the neutron and/or proton pairing energies for other daughter nuclei. Gardner and Yu (1964) have shown that equations (3) and (4) lead to the following relationship between (n,  $x$ ) reaction cross sections in neighboring isotopes:

$$\frac{\sigma(Z, A + 1)}{\sigma(Z, A)} = \exp 2 \{ [a(E_m - U_x)]_{A+1}^{1/2} - [a(E_m - U_x)]_A^{1/2} \} \quad (5)$$

In equation (5),  $a$  is the nuclear level density parameter widely used in statistical model calculations. The value of  $a$  ranges from  $A/40$  to  $A/10$  MeV<sup>-1</sup>.

Chatterjee (1963) has tried, with some success, to include shell effects in the (n, p) and (n,  $\alpha$ ) reaction cross sections to reduce the discrepancies at shell closure. On the other hand, Pai et al. (1971) found that attempts to introduce shell and pairing effects explicitly into their statistical model calculations of (n, p) cross sections gave poorer agreement with the experimental data.

In the attempts made so far to develop formulas for calculating (n, p) and (n,  $\alpha$ ) cross sections at 14 to 15 MeV, lack of accurate nuclear parameters (like level density and pairing energy parameters) has hindered progress towards the refinements which must be included in the statistical model calculations as well as the empirical approach to predict the neutron-induced reaction cross sections. Thus, reliable and accurate experimental data is needed, particularly for reactions involving the less abundant isotopes of the target nuclei.

An alternate approach for calculating  $\sigma(n, p)$  and  $\sigma(n, \alpha)$  entails the use of the Hauser-Feshbach theory (1952) which relates the average compound nucleus cross section for a particular reaction to the transmission coefficients for all allowed channels. A test of the validity of the Hauser-Feshbach theory, however, calls for accurate experimental data on partial cross sections for (n, p) and (n,  $\alpha$ ) reactions in addition to other available channels. Such partial cross section data are far more scarce than the total cross section data. The Hauser-Feshbach theory will not, therefore, be given further consideration.

The present work is intended to provide a direct comparison with earlier studies of silicon and iron. Consequently it is considered desirable to compare the measured cross-sectional values with the Gardner et al. (1962, 1964, 1967) and Pai et al. (1971) values which have been used by earlier authors.

### Experimental Procedure

A standard neutron activation experimental arrangement (Figure 1) was used in bombarding high purity silicon and iron targets with the neutrons produced by 150 KeV deuterons striking a tritium target. A spectroscopically pure aluminum target\* was bombarded simultaneously with the experimental targets in order to determine the instantaneous neutron flux.

\* This material was chosen since the  $^{27}\text{Al}(n, \alpha)^{24}\text{Na}$  cross section is among the most precisely known data (Ranakumar et al. 1968). Spectroscopically pure aluminum targets (purity = 99.99%) were used in this investigation.

Equations (3) and (4) do not incorporate any specific

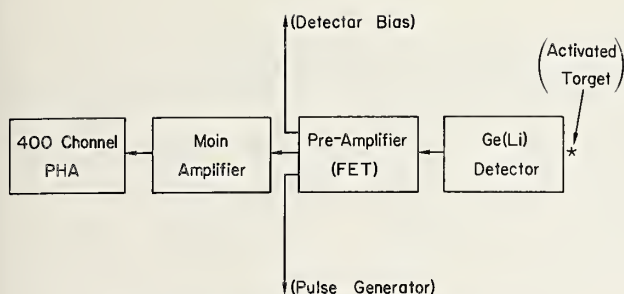


FIG. 1—Diagram of experimental arrangement.

The targets were irradiated at fluxes ranging from  $10^7$  to  $10^8$  n/cm<sup>2</sup>/s for a time determined by the half-life of the residual radionuclide to be investigated. The experimental and monitor targets were discs of identical dimensions, 2 cm in diameter and 1/4 cm thick. This target size was dictated by the dimensions of the standard calibrated gamma ray sources (<sup>133</sup>Ba, <sup>109</sup>Cd, <sup>137</sup>Cs, <sup>60</sup>Co, <sup>54</sup>Mn, and <sup>22</sup>Na) used to calibrate the response of two lithium drifted germanium detectors (5 cm<sup>2</sup> × 6 mm; 6 cm<sup>2</sup> × 8 mm) used to measure the gamma ray spectra from the residual radionuclides in silicon and iron. The resolution of the detection system (detector plus electronics) was < 6 KeV (FWHM) at 1332 KeV. A preliminary experiment indicated that the aluminum disc activity—and hence the incident neutron flux—was independent of the sequence in which the target and the monitor discs were placed. Hence, the experimental target was placed ahead of the monitor target in all subsequent studies.

### Si(n, x) Reactions

**Measurements and Results**—Experimentally observed intensities of characteristic  $\gamma$ -rays from irradiated natural silicon targets were used to calculate various  $Si(n, x)$  cross sections. The  $^{28}Si(n, p)^{28}Al$  reaction contributes a strong single escape peak at the same energy (1.78 MeV - 0.51 MeV = 1.27 MeV) as the major gamma ray from the  $^{28}Si(n, p)^{28}Al$  reaction. However, a sequential spectral measurement from the irradiated silicon disc, coupled with a precise knowledge of the profile of a 1.78 MeV gamma ray in the spectrometer, allowed an easy separation of the contributions from the  $^{28}Si(n, p)^{28}Al$  and  $^{29}Si(n, p)^{29}Al$  reactions under the 1.27 MeV peak. The 1.78 MeV gamma ray profile in the spectrometer was obtained by measuring the difference in the spectrum observed from a polyethylene capsule 2 cm in diameter and 1/4 cm thick with and without  $P_2O_5$  powder in it bombarded with neutrons. The difference spectrum is expected to give the following contributions from the various possible  $^{31}P(n, x)$  reactions (none of the energetically possible  $O(n, x)$  reactions are expected to interfere with the profile of the 1.78 MeV gamma ray from the  $^{31}P(n, \alpha)^{28}Al$  reaction): 0.51 MeV  $\gamma$ -ray from  $^{31}P(n, 2n)^{30}P \rightarrow ^{30}Si$ , 1.48 MeV  $\gamma$ -ray from  $^{31}P(n, p)^{31}Si \rightarrow ^{31}P$  and 1.78 MeV  $\gamma$ -ray from  $^{31}P(n, \alpha)^{28}Al \rightarrow ^{28}Si$ . Thus, the 1.78 MeV gamma ray from the  $^{31}P(n, \alpha)^{28}Al$  reaction is sufficiently well separated from other gamma rays to permit an easy and reliable computation of the ratio of the single

escape peak intensity to the total capture peak intensity previously mentioned.

Because of the short half-life of the  $^{30}Al$  (3.27 sec) produced in  $^{30}Si(n, p)^{30}Al$  reactions, a slightly different procedure was used for this reaction. In this procedure, the silicon and aluminum samples were bombarded for a period of 5 minutes. This time interval was chosen to ensure measureable activity in the aluminum disc. Immediately after the end of the bombardment, the gamma spectrum accumulation from the two targets in situ was started and continued for a period of 1 minute. During this time, essentially all  $^{30}Al$  nuclei decayed. This spectrum was stored in the first half of the memory of a pulse height analyzer. Next, the spectrum accumulation was continued in the second half of the memory for an additional minute. A comparison of the two spectra was then made to obtain the  $^{30}Al \beta^- ^{30}Si$  contribution. In this comparison, attention was focused on the 3.51 MeV gamma ray rather than on the 1.27 MeV gamma ray which cannot be separated from the  $^{28,29}Si(n, p)$  spectra or the 2.23 MeV gamma ray which cannot be separated from the single escape peak due to the 2.75 MeV gamma ray resulting from the  $^{27}Al(n, \alpha)^{24}Na$  reaction. No distinct gamma peak ascribable to the  $^{30}Si(n, p)^{30}Al \beta^- (^{30}Si + \text{gamma rays})$  reaction was observed.

From the measured values of the intensities of the total capture peaks, after allowing for isotope effects, saturation effects, decay branchings, and decay corrections, the values of the  $^{28,29,30}Si(n, p)$  and  $^{30}Si(n, \alpha)$  cross sections were calculated. The relevant branching ratios needed for the analysis of individual reactions were taken from Lederer et al. (1967) and Endt and Van der Leun (1973). A summary of the cross-sectional results is given in Table 1. The quoted cross-sectional errors were arrived at by combining the aluminum monitor reaction cross-sectional error with the statistical errors in the critical gamma ray intensities and the errors associated with the calibration sources. For  $(n, p)$  reactions, it has been assumed that  $(n, d)$  or  $(n, np)$  reactions in heavier isotopes do not make significant contributions to the population of the radionuclides produced in the  $(n, p)$  reaction in the lighter isotope (see Discussion).

By using the measured value of the  $^{30}Si(n, \alpha)$  reaction cross section, the  $^{28}Si(n, \alpha)$  and  $^{29}Si(n, \alpha)$  reaction cross sections were calculated by the following approach. As indicated in the Introduction, Gardner and Yu (1964) have derived a semiempirical equation (5), based on the statistical model, for the relative  $(n, \alpha)$  cross sections at 14.5 MeV neutron energy for isotopes of a given element in the range  $Z = 6$  to 30. The equation involves parameters which are functions of the incident neutron energy, the nuclear level density in the residual nucleus, and the pairing energy in the daughter nucleus. In this equation, the effective coulomb barrier height for alpha particles is given by

$$U_\alpha = \frac{2.058(Z-2)}{(A-3)^{1/3} + 4^{1/3}} \left[ 1 - \frac{1.13}{(A-3)^{1/3}} \right] \text{MeV}$$

Since equation (5) predicts only the ratios of cross sections, it is not very sensitive to errors in  $a$  ( $a = 0.14 \text{ MeV}^{-1}$ ).

Substituting appropriate values of the various pa-



TABLE 1  
Summary of  $Si(n, p)$  and  $Si(n, \alpha)$  reaction cross section values at 14.5 MeV neutron energy

Nuclear Reaction	Prominent $\gamma$ -Ray and its Relative Probability/Decay	Present Results (mb) (a)	Best Available Experimental Results (mb)				Theoretical Results (mb)		
			Cuzzocrea and Perillo (1971)	Ranakumar et al. (1968) (a)	Pasquerelli (1967) (b)	Robertson et al. (1973) (c)	Levkovskii (1964)	Gardner (1962)	Gardner and Rosenblum (1967)
$^{28}Si(n, p)$	1.78 MeV, 1 $\gamma$ /decay	$213 \pm 18$	$160 \pm 16 \rightarrow 355 \pm 40$ ( $212.8 \pm 14.7$ ) <sup>f</sup>	$252 \pm 15$	$222 \pm 12$	$265 \pm 7.5$	240	240	187.1
$^{29}Si(n, p)$	1.27 MeV, 0.91 $\gamma$ /decay	$116 \pm 18$	$22.7 \pm \rightarrow 130 \pm 16$ ( $75.8 \pm 24.5$ ) <sup>f</sup>	$130 \pm 16$	$22.7 \pm 1.0$	$131 \pm 13.6$	70	120	113.4
$^{30}Si(n, p)$	3.51 MeV, 0.33 $\gamma$ /decay	$< (6 \pm 6)$	—	$< 7$	—	—	22	60	90.0
							Gardner and Yu (1964)	Chatterjee (1963)	
$^{28}Si(n, \alpha)$	—	$152 \pm 21^d$	—	—	—	—	103.7	$140 \pm 75\%$	—
$^{29}Si(n, \alpha)$	—	$18 \pm 5^e$	—	—	—	—	131.4	—	—
$^{30}Si(n, \alpha)$	840 KeV, 0.71 $\gamma$ /decay	$74 \pm 10$	$45.9 \pm 25 \rightarrow 175 \pm 18$ ( $103.9 \pm 28.5$ ) <sup>f</sup>	$68 \pm 8$	$175 \pm 18$	$90 \pm 11$	50.3	$70 \pm 75\%$	—

(a)— $\sigma_{n\alpha}(^{27}Al) = 114 \pm 6$  mb

(b)— $\sigma_{n,n}(^{63}Cu) = 511 \pm 15$  mb

(c)— $\sigma_{n,p}(^{56}Fe) = 109.8 \pm 2.9$  mb

(d)—not measured, but calculated from  $\sigma_{n\alpha}(^{30}Si)$

(e)—deduced from  $\sigma_{n\alpha}(^{28}Si)$  and experimental cross section ratio for  $\sigma_{n\alpha}(^{28}Si)/\sigma_{n\alpha}(^{29}Si)$  from Anderson (1962)

(f)—weighted average values Cuzzocrea and Perillo (1971)

rameters in equation (5) gives the following relative values of  $Si(n, \alpha)$  reaction cross sections:

$$\sigma_{n\alpha}(^{28}Si)/\sigma_{n\alpha}(^{29}Si) = \frac{1.00}{1.27} = 0.787,$$

$$\sigma_{n\alpha}(^{29}Si)/\sigma_{n\alpha}(^{30}Si) = \frac{1.270}{0.485} = 2.62$$

Since errors in the chosen values of the pairing energy  $\delta$  affect greatly the predicted cross-sectional values for adjacent isotopes, but not as much the predicted values for alternate isotopes (where  $\delta$  values are the same), it was decided to obtain the  $\sigma_{n\alpha}(^{28}Si)$  value from the measured  $\sigma_{n\alpha}(^{30}Si)$  value by using the predicted ratio of these reaction cross sections, that is,

$$\sigma_{n\alpha}(^{28}Si)/\sigma_{n\alpha}(^{30}Si) = \frac{1.000}{0.485} = 2.06$$

In this manner,  $\sigma_{n\alpha}(^{28}Si)$  has been calculated to be  $152 \pm 21$  mb based on the measured value of  $74 \pm 10$  mb for  $\sigma_{n\alpha}(^{30}Si)$ . The  $^{29}Si(n, \alpha)^{26}Mg$  reaction cross section was then calculated on the basis of an experimentally measured value (Anderson 1962) of

$$\sigma_{n\alpha}(^{28}Si)/\sigma_{n\alpha}(^{29}Si) = 8.5 \pm 1.2$$

**Discussion**—In discussing the isotopic cross-sectional results, the possibility of interference from competing reactions in neighboring isotopes should be considered. The relative contributions of the various reactions involved are strongly dependent on their respective  $Q$ -values. However, the values  $E_m = E_n + Q_{nx} - \delta$  for the competing reactions are very small, and hence their contributions to the primary channels may be ignored. In line with this argument and coupled with the relative abundance of various isotopes of silicon, the observed  $^{28}Al$  and  $^{29}Al$  decays

have been attributed entirely to  $^{28}Si(n, p)^{28}Al$  and  $^{29}Si(n, p)^{29}Al$  reactions respectively.

An examination of the data in Table 1 shows that the calculated values based on the statistical nuclear model predict  $^{28}Si(n, p)$  and  $^{29}Si(n, p)$  reaction cross sections reasonably well, but the measured value of the  $^{30}Si(n, p)^{30}Al$  reaction cross section is in disagreement with all predicted values. Part of this disagreement could be due to uncertainty in the level of  $^{30}Al$  involved. A  $T_{1/2} = (72.5 \pm 1.5)$  sec activity with unknown gamma decay has been ascribed (Peeters 1963) to  $^{30m}Al$ . If the  $^{30}Si(n, p)^{30}Al$  reaction populates this level appreciably and if this state decays by direct beta emission to  $^{30}Si$ , the experimental value of  $\sigma_{np}(^{30}Si)$  could be in considerable error. However, the existence of a  $^{30m}Al(72.5 \text{ secs})$  isomer yet remains to be confirmed (Grench et al. 1971).

The predicted and measured values of the  $^{30}Si(n, \alpha)$  reaction cross section are in reasonably good agreement. However, the calculated value of  $\sigma_{n\alpha}(^{29}Si)$  does not agree with the value computed in the present work. An investigation of the alpha spectrum in  $^{29}Si(n, \alpha)^{26}Mg$  reaction in an enriched  $^{29}Si$  target is needed to resolve this difference. The  $^{28}Si(n, \alpha)$  cross section computed using the measured  $^{30}Si(n, \alpha)$  cross section also agrees with the theoretical prediction.

As seen in Table 1, the values of cross sections reported by Ranakumar et al. (1968) and Pasquarelli (1967) are in serious disagreement except for the  $^{28}Si(n, p)^{28}Al$  reaction. Part of this difference could be ascribed to the measurement techniques used by the two groups. Pasquarelli (1967) used a thin window GM counter to measure the beta activity in the product nuclei. Self-absorption in the target as well as scattering in the GM window can lead to considerable errors in the measured cross sections, particularly for the less abundant isotopes. Our measure-

TABLE 2  
Summary of  $Fe(n, p)$  and  $Fe(n, \alpha)$  Reaction Cross-sectional Values at 14.5 MeV Neutron Energy

Nuclear Reaction	Prominent $\gamma$ -Ray and Its Relative Prob/Decay	Present Results (mb) (a)	Best Available Previous Results (mb)				Theoretical Results (mb)			
			Cuzzocrea and Perillo (1971)	Pai et al. (1971)	Rao and Fink (1967)	Gardner et al. (1962, 1964, 1967)	Pai et al. (1971)	Uhl (1970)	Levkovskii (1974)	
$^{54}Fe(n, p)$	835 KeV, $1\gamma$ /decay	$522 \pm 28$ ( $511 \pm 28$ ) <sup>b</sup>	$254 \pm 28 \rightarrow 382 \pm 13$ ( $319 \pm 19$ ) <sup>c</sup>	$<510$	$259 \pm 26$	443.1	445	—	300	
$^{54}Fe(n, \alpha)$	320 KeV; 0.09 $\gamma$ /decay	$140 \pm 8$	$90 \pm 10 \rightarrow 270 \pm 135$ ( $101.6 \pm 6.7$ ) <sup>c</sup>	$109 \pm 10$	$90 \pm 10$	111.4	—	—	120	
$^{56}Fe(n, p)$	845 KeV; 0.986 $\gamma$ /decay	$149 \pm 10$ ( $148 \pm 10$ ) <sup>b</sup>	$72 \pm 7 \rightarrow 144 \pm 19$ ( $106.4 \pm 3.4$ )	$118 \pm 4$	—	118.4	126	110	100	
$^{57}Fe(n, p)$	(122 KeV + 136 KeV); 0.84 $\gamma$ /decay	$33 \pm 2$ ( $32 \pm 2$ ) <sup>b</sup>	$50 \pm 8 \rightarrow 71 \pm 7$ ( $61.2 \pm 10.5$ ) <sup>c</sup>	$65 \pm 7$	—	54.1	58	—	58	
$^{58}Fe(n, p)$	467 KeV, 0.23 $\gamma$ /decay	$38 \pm 27$	$23 \pm 4$	$23 \pm 4$	—	19.4	25	—	—	
$^{58}Fe(n, \alpha)$	—	—	$21.5 \pm 2^*$ $10.8 \pm 1.0^{**}$	—	—	—	—	—	14	

\* Cuzzocrea and Perillo (1971)

\*\* (N. C. Dyer and J. H. Hamilton, J. Inorg. Nucl. Chem **34**, 1119, 1972)

(a)—These values are based on  $\sigma_{na}(^{27}Al) = 114 \pm 6$  mb

(b)—The bracketed quantities give cross section values after allowing for the competing reactions. Competing reactions included are:

$^{54}Mn : ^{54}Fe(n, p); ^{54}Mn(n, 2n)$

$^{56}Mn : ^{56}Fe(n, p); ^{57}Fe(n, np)$

$^{57}Mn : ^{57}Fe(n, p); ^{58}Fe(n, np)$

(c)—Weighted average values.

$^{55}Mn$  was an impurity in the target (0.082%)

ments are in better agreement with the results of Ranakumar (1968).

### Fe(n, $\alpha$ ) Reactions

**Measurements and Results**—Cross sections for the  $^{54,56,57,58}Fe(n, p)$  and  $^{54}Fe(n, \alpha)$  reactions were computed from the measured intensities of gamma rays associated with product nuclei decays. The errors in the measured cross sections were computed in the same way as for silicon. On the basis of the measured intensity of the 835 KeV gamma ray and the decay scheme (Lederer et al. 1967; Nuclear Data Sheets 1970) of  $^{54}Mn$ , the  $^{54}Fe(n, p)^{54}Mn$  cross section was calculated to be  $522 \pm 28$  mb. Similarly, the observed

intensity of the 320 KeV gamma ray associated (Nuclear Data Sheets 1970) with the decay of  $^{51}Cr$  leads to a cross section of  $140 \pm 8$  mb for the  $^{54}Fe(n, \alpha)^{51}Cr$  reaction.

In the case of the  $^{56}Fe(n, p)^{56}Mn$  reaction, the decay scheme (Tirsell et al. 1974) for  $^{56}Mn \xrightarrow{\beta^-} ^{56}Fe$  indicates that 98.6 percent of the  $^{56}Mn$  decays produce an 845 KeV gamma ray. Using this percentage and the observed photopeak intensity of the 845 KeV gamma ray, the cross section for the  $^{56}Fe(n, p)^{56}Mn$  reaction has been calculated to be  $149 \pm 10$  mb.

The  $^{57}Fe(n, p)^{57}Mn$  reaction is followed by the  $\beta^-$ -decay of  $^{57}Mn$  to  $^{57}Fe$ . It is expected (Nuclear Data Sheets 1974) that 122 KeV and 136 KeV gamma rays should be present in 84 percent of  $^{57}Mn$  decays. Based on this percentage and the measured combined intensities of the two gamma rays, the cross section for the  $^{57}Fe(n, p)^{57}Mn$  reaction was determined to be  $33 \pm 2$  mb.

For the  $^{58}Fe(n, p)^{58}Mn$  reaction, the product nucleus  $^{58}Mn$  decays by  $\beta^-$ -emission to  $^{58}Fe$ . The decay scheme (Tirsell et al. 1974) for  $^{58}Mn \xrightarrow{\beta^-} ^{58}Fe$  indicates that 88 percent of the decays produce an 810 KeV gamma ray and 23 percent of the decays produce a 467 KeV gamma ray. The 810 KeV gamma ray could not be observed due to the presence of a strong 845 KeV gamma ray from the  $^{56}Mn \xrightarrow{\beta^-} ^{56}Fe$  decay. Hence, attention was focused on the weak 467 KeV gamma ray. On the basis of the measured intensity of this gamma ray, the cross section for the  $^{58}Fe(n, p)^{58}Mn$  reaction was calculated to be  $35 \pm 25$  mb.

**Discussion**—The values of  $(n, p)$  cross sections in various stable isotopes of iron and the  $(n, \alpha)$  cross

TABLE 3

Summary of  $(n, p)$  Cross-sectional Trends in Various Isotopes of Iron

Reaction	Relative Cross Section (Experimental)	Relative Cross Section (Calculated)				
		Gardner et al. (1967)	Pai et al. (1963)			
			(i)	(ii)	(iii)	
$^{54}Fe(n, p)^{54}Mn$	1.000	1.000	1.00	1.00	1.00	
$^{56}Fe(n, p)^{56}Mn$	( $0.29 \pm 0.04$ )	0.27	0.28	0.32	0.29	
$^{57}Fe(n, p)^{57}Mn$	( $0.06 \pm 0.01$ )	0.12	0.13	0.11	0.08	
$^{58}Fe(n, p)^{58}Mn$	( $0.07 \pm 0.05$ )	0.04	0.06	0.04	0.01	

(i) No explicit shell dependence of  $a$  or  $\delta$ .

(ii) Specific shell dependence of  $\delta$  included but not of  $a$ .

(iii) Specific shell dependence of  $a$  only included.



section in  $^{54}\text{Fe}$ , obtained after allowing for all competing reactions are summarized\*\* in Table 2. The calculated values of Gardner et al. (1962, 1964, 1967) and Pai et al. (1971) obtained by using the semi-empirical formalism summarized in Section I are also included in this table, along with the best available previous experimental results. The trends in  $(n, p)$  cross-sectional values in various isotopes of iron observed in the present study are summarized in Table III. The trends predicted on the basis of statistical model calculations (Lardner et al. 1962, 1964, 1967; Pai et al. 1971) are also included in this table for the sake of comparison. The experimental values are in good agreement with the calculated values of Pai (Table 3 last column), except in the cases of  $^{57}\text{Fe}(n, p)^{57}\text{Mn}$  and  $^{58}\text{Fe}(n, p)^{58}\text{Mn}$  reactions. It is planned to reexamine the  $^{57}\text{Fe}(n, p)^{57}\text{Mn}$  reaction by studying the prompt proton spectrum using enriched targets. The error in the  $^{58}\text{Fe}(n, p)^{58}\text{Mn}$  cross section is too large to permit any reliable conclusions regarding this reaction.

#### Literature Cited

Anderson, G. L. 1962. *Z. Naturforsch.* **17a**:238.  
Chatterjee, A. 1963. *Nucl. Phys.* **47**:511; **49**:686.

\*\* Preliminary results were reported by Singh (1972).

Cuzzocrea, P., and E. Perillo. 1971. *Il Nuovo Cemento*. **4A**:251.  
Dyer, N. C., and J. H. Hamilton. 1972. *J. Inorg. Nucl. Chem.* **34**:1119.  
Endt, P. M., and Van der Leun. 1973. *Nucl. Phys.* **214A**:1-625.  
Gardner, D. G. 1962. *Nucl. Phys.* **29**:373.  
Gardner, D. G. and S. Rosenblum. 1967. *Nucl. Phys.* **A96**:121.  
Gardner, D. G. and Yu-Wen Yu. 1964. *Nucl. Phys.* **60**:49.  
Grench, H. A., A. D. W. Jones, and R. W. Nightingale. 1971. *Nucl. Phys.* **A166**:670.  
Hauser, W. and H. Feshbach. 1952. *Phys. Rev.* **87**:366.  
Lederer, C. M., J. M. Hollander, and I. Perlman. 1967. *Tables of Isotopes*. Sixth Ed. John Wiley and Sons, New York, pp. 166-168, p. 187.  
Levkovskii, V. N. 1964. *Soviet Phys. JETP*. **18**:213.  
——— 1974. *Soviet J. Nucl. Phys.* **18**:361.  
Nuclear Data Sheets, Section B. 1970. Vol. 3. Academic Press, New York.  
Pai, H. L., R. L. Clarke, and W. G. Cross. 1971. *Nucl. Phys.* **A164**:526.  
Pasquarelli, A. 1967. *Nucl. Phys.* **A93**:218.  
Peeters, E. 1963. *Phys. Lett.* **7**:142.  
Ranakumar, N., E. Kondaiah, and R. W. Fink. 1968. *Nucl. Phys.* **A122**:679.  
Rao, P. V., and R. W. Fink. 1967. *Phys. Rev.* **154**:1023.  
Robertson, J. C., B. N. Audric, and P. Kolkowski. 1973. *J. Nucl. Energy*. **27**:139.  
Singh, J. J. 1971. *USAEC-CONF-710301*. **2**:882.  
Singh, J. J. 1972. *Trans. Am. Nucl. Soc.* **15**:147.  
Tirsell, K. G., L. G. Multhauf, and S. Raman. 1974. *Phys. Rev. (c)*. **10**:785.  
Uhl, M. 1970. *Acta Physica Austriaca*. **31**:245.

# Length of Snow Season Across a Portion of the Northern Blue Ridge Mountains in Virginia

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Center for Advanced Studies  
University of Virginia*

(Received, Nov. 1, 1976    Revised, Feb. 24, 1977)

Roger A. Pielke, Assistant Professor of Environmental Science and Member, Center of Advanced Studies of UVA, Received B.A. (1968), Towson State College and M. S. (1969) and Ph.D. (1973), Penn. State University. Recipient of NOAA's Distinguished Authorship Award (1974) and American Meteorological Society's Leroy Meisinger Award (1977).



## Introduction

Weather, in its most basic definition, is the atmospheric situation in which each of us exists at any given time. Over Virginia, weather patterns are complex, not only because of the longitudinal and the latitudinal variations across the state, but also because of altitude differences. The topography in the state varies from flat and near sea level for some distance inland from the Atlantic coast and shores of the Chesapeake Bay, to the rugged and comparatively high terrain of the Appalachian Mountains in the western section of the state.

In this paper, one particular component of weather for a specific region of Virginia is discussed, namely the length of period during the winter in which snow lies on the ground. The paper will document, for three sites in the region near and in the northern Blue Ridge Mountains, the variations of snow cover as a function of elevation for a number of years. It will be shown that in most winters a sufficient snow cover exists in the mountains to undertake winter sports activities.

## Methods and Results

Snowfall and duration of snow on the ground for selected climatological sites are available from the publication *Climatological Data, Virginia* as prepared by the National Climatic Center in Asheville, North Carolina. These observations are supposed to be

made at several locations at the site and are intended to represent the total snowfall and representative snow depth over the area. The effects of drifting, along with horizontal variations in melting, however, often make the interpretation of these measurements very difficult. In fact, it would be useful to have values of the standard deviation of the snow depth and snowfall, as well as their mean values.

Three sites were chosen for the study: Warrenton, east of the Blue Ridge at an altitude of 500 ft (164 m); Big Meadows, near the crest of the Blue Ridge at 3535 ft (1160 m); and Dale Enterprise, at 1400 ft (459 m) to the west in the Shenandoah Valley. The locations of these sites are indicated on Figure 1.

The data were evaluated for the winters of 1958–59 through 1974–75 and cataloged into days with measurable amounts, greater than 5 in. (12.7 cm), greater than 10 in. (25.4 cm), and greater than 15 in. (38.1 cm) of snow on the ground along with the maximum depth for that season, as shown in Table 1. The results are as one would expect, with the high elevation station of Big Meadows recording higher maximum amounts and longer durations of snow cover than the other stations. Dale Enterprise at a somewhat higher elevation than Warrenton and further inland, to the west of the Blue Ridge Mountains, is generally second in maximum amounts and duration. The averages and standard deviations for each category are also listed on the table.

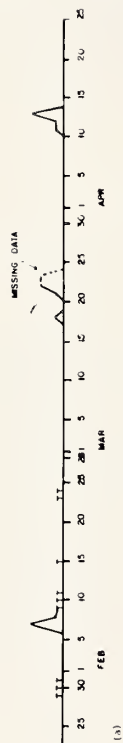
For Warrenton and Dale Enterprise, the occurrence of snow depths greater than 15 in. (38.1 cm), or even 10 in. (25.4 cm), is a rare event. On the other



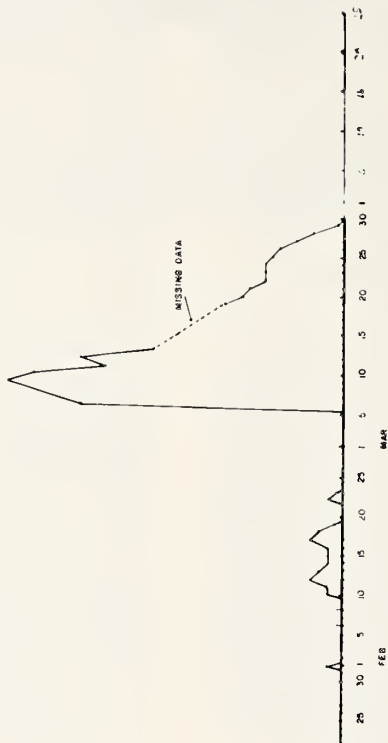
FIG. 1—Locations of Warrenton, Big Meadows and Dale Enterprise in Virginia



BIG MEADOWS WINTER 1972-73  
ELEVATION 3535 FT MSL



BIG MEADOWS WINTER 1961-62  
ELEVATION 3535 FT MSL



BIG MEADOWS WINTER 1967-68  
ELEVATION 3535 FT MSL

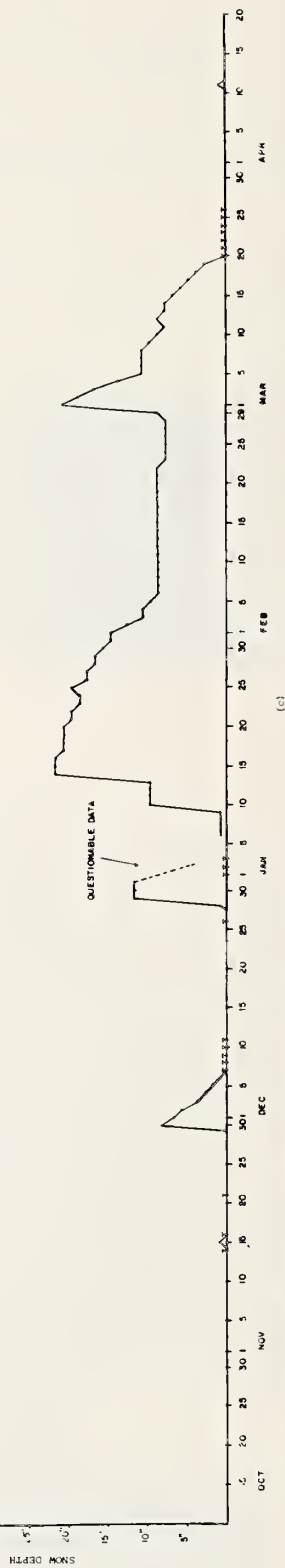


Fig. 2—Plots of snow depth against time at Big Meadows, Virginia, for several winter seasons (a) 1972-73, (b) 1961-62, and (c) 1967-68

TABLE 1

Number of days with a) measurable; b) greater than 5 inches (12.7 cm); c) greater than 10 inches (25.4 cm); d) greater than 15 inches (38.1 cm) of snow on the ground along with e) maximum depth of snow on the ground in inches (cm).

Season	Warrenton					Big Meadows					Dale Enterprise				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
1974-1975	9	0	0	0	4 (10.2)	57	8	3	0	12 (30.5)	17	0	0	0	5 (26.2)
1973-1974	21	2	0	0	9 (22.9)	35	7	4	0	14 (35.6)	18	6	0	0	8 (20.3)
1972-1973	5	0	0	0	1 (2.54)	29	0	0	0	4 (10.2)	4	0	0	0	2 (5.1)
1971-1972	18	0	0	0	4 (10.2)	46	17	11	7	20 (50.8)	19	5	0	0	8 (20.3)
1970-1971	37	6	0	0	10 (25.4)	63	9	6	4	18 (45.7)	38	4	2	0	12 (30.5)
1969-1970	45	14	4	0	12 (30.5)	76	12	4	0	12 (30.5)	38	5	0	0	8 (20.3)
1968-1969	22	2	0	0	7 (17.8)	55	24	6	3	25 (63.5)	21	2	0	0	7 (17.8)
1967-1968	39	3	0	0	8 (20.3)	92	72	32	22	22 (55.9)	47	17	0	0	10 (25.4)
1966-1967	44	12	0	0	9 (22.9)	72	35	6	0	13 (33.0)	37	8	0	0	7 (17.8)
1965-1966	28	18	12	10	22 (55.9)	48	26	20	15	35 (88.9)	27	21	14	9	22 (55.9)
1964-1965	35	1	0	0	6 (15.2)	48	10	4	0	12 (30.5)	29	3	0	0	7 (17.8)
1963-1964	45	8	0	0	9 (22.9)	104	54	35	13	18 (45.7)	48	21	0	0	10 (25.4)
1962-1963	35	15	0	0	9 (22.9)	80	32	0	0	9 (22.9)	54	17	0	0	9 (22.9)
1961-1962	16	0	0	0	4 (10.2)	70	23	17	14	42 (106.7)	39	8	7	6	24 (61.0)
1960-1961	53	31	5	0	15 (38.1)	91	46	32	22	42 (106.7)	50	22	3	0	15 (38.1)
1959-1960	37	15	4	0	12 (30.5)	58	47	41	40	38 (96.5)	47	15	2	0	13 (33.0)
1958-1959	12	0	0	0	4 (10.2)	42	4	0	0	10 (25.4)	12	0	0	0	4 (10.2)
Mean	29.5	7.5	1.5	0.6	8.5 (21.6)	62.7	25.1	13.0	8.2	20.4 (51.8)	32.1	9.1	1.6	.88	10.1 (25.7)
Standard Deviation	14.3	8.8	3.2	2.43	5.0 (12.7)	21.1	20.2	13.8	11.4	12.0 (30.5)	15.0	8.0	3.7	2.55	5.8 (14.7)

hand, depths greater than 15 in. (38.1 cm) at Big Meadows occur almost every winter, although none have occurred in the last three years.

To illustrate the variations of snow depth for three characteristic winters at Big Meadows, the snow depth versus time is plotted in Figures 2a to 2c. The slope of the line is positive during snowfall events and negative during melt and ablation episodes. Figure 2a is an example of an extreme minimum of snow activity with minor snow events widely dispersed during the season, while Figure 2b, in contrast, is an example of a winter with minimal snow activity until a major event in March. The last figure is representative of a winter with a long period of continuous and comparatively deep snows. The notation of missing data on the figures indicates observations were not taken on these dates, while the label "questionable data" for several days for the 1967-68 winter was given because the observation of a rapid removal of the snow cover was not consistent with the recorded maximum temperatures which remained below freezing during that period.

### Conclusions

Several conclusions concerning the snow climatology of the northern Blue Ridge are possible from this data:

1. The duration of snow cover and maximum depth have decreased in recent years at all elevations. Because of the nature of climatic fluctuations, no indication of future snow conditions in the region should be interpreted from this data.
2. Maximum snow depth and duration at the lower elevations occur frequently enough to promise winter conditions each year, but the

lack of significant periods of deep snow generally precludes the use of the snow for recreational activities such as snowshoeing, cross-country skiing or snowmobiling.

3. At the higher elevations, on the other hand, snow depths and durations are often sufficient for winter recreation activities. Although it is well known (see Leffler and Foster 1974) the Allegheny Plateau in West Virginia is superior in the amounts of snow, the Blue Ridge Mountains can also play an important role in winter sports, and facilities should be encouraged at higher elevations to take advantage of this resource. As shown by Pielke and Mehring (1977), the mean monthly temperatures at the same elevation in the Allegheny Plateau and the Blue Ridge are nearly the same; thus when snow falls it is as likely to remain there as in the Plateau region to the west.

### Acknowledgements

Peter Mehring and Donna Hensley are thanked for accurately reducing the data to manageable form. Barbara Dinsmore typed the manuscript. This work was supported under NSF Grant ATM-74-12559 A01.

### Literature Cited

- Leffler R. L., and J. L. Foster. 1974. Snowfall on the Allegheny Plateau of Maryland and West Virginia. *Weatherwise*, 27:199-201.
- Pielke, R. A., and P. Mehring. 1977. Use of mesoscale climatology in mountainous terrain to improve the spatial representation of mean monthly temperatures. *Mon. Wea. Rev.*, 105:108-112.



## NEWS AND NOTES

### THE EDITORIAL BOARD



Kuldip P. Chopra, *editor*, was born in Srinagar (Kashmir) on March 25, 1932. He received his B.Sc. (Honors), M.Sc. and Ph.D. degrees in physics from University of Delhi in 1951, 1953, and 1960 respectively, and pursued his postdoctoral work at the University of Maryland. He has held faculty positions at the Universities of Southern California and Miami, Polytechnic Institute of Brooklyn, and Nova University. Since 1969, he has been professor of physics and geophysical sciences at Old Dominion University. He headed Melpar's Space Science Laboratory, and directed the summer schools on environmental and planetary sciences at the University of Miami.

Dr. Chopra's instructional (at all college levels) and research interests span several disciplines in science and engineering with principal emphasis on applied physics of fluids. He has some 40 publications in aeronautics and astronautics, and environmental and space physics; two of these are book-length. In recognition of his research in areas of plasma physics and interactions of space vehicles with ionized environment, the American Physical Society elected him a fellow in 1961, and he was UNESCO-sponsored invited speaker at the 1965 meeting of the International Astronautical Federation. For his identification and interpretation of satellite photographs of vortex streets leeward of islands, he received the first Melpar Author of the Year Award in 1965. He won the 1974 Shelton Horsley Research Award of the Virginia Academy of Science for his research dealing with the climatology and oceanography of islands.

Dr. Chopra is a *fellow* of the American Physical Society, a life member of the American Geophysical Union, and a member of the American Association for Advancement of Science, American Institute of Aeronautics and Astronautics, and American Meteorological Society. Through his membership, he supports APS' South-Eastern Section and Divisions on fluid dynamics and cosmic ray physics. He is a continuing member on AIAA's national technical committee on space science and astronomy, and is Chairman of the Subcommittee on Annual Space Science Award for 1978.

He joined the Virginia Academy of Science in 1974, and is a cofounder and past chairman of the Environmental Sciences Section. He is a continuing member of the Council and Publications Committee.



Michael N. Bishara (*science and society*) was born in Alexandria, Egypt in 1933. He received his baccalaureate degree in aeronautical

engineering from Cairo University, and his M.S. and Ph.D. degrees in aerospace engineering from the University of Virginia. He has held positions of research scientist at U. Va., and of engineering specialist at AiResearch Manufacturing Company. He chairs the engineering division at Southwest Community College.

Dr. Bishara holds memberships in the American Society for Engineering Education, Virginia Mining Institute, and Sigma Xi. He is a contributing member of the Virginia Academy of Science, which he has served with great devotion in various capacities.

Dr. Bishara has authored more than 20 papers. His research interests include low-density gas dynamics, gas-surface interactions, and coal mining technology. He received the Abu Zahra Award for aeronautics (Cairo University) and the Minta Martin First Paper Award (American Institute of Aeronautics and Astronautics).



Auzville Jackson, Jr. (*business manager*) received his B.S. (1950) in metallurgical engineering from VPI and SU and Juris D. (1954) from George Washington University. He has been a patent examiner with the U.S. Patent Office (1950-52), patent adviser, U.S. Department of Navy (1952-56), and patent counsel, Reynolds Metals Co. (1956-61). Since 1961, he has been with Robertshaw Controls Company where he is Chief Patent Counsel and Assistant Vice-President for Technology. He has also been an adjunct associate professor of law at the University of Richmond since 1973.

Dr. Jackson has played an earnest role in every professional society he holds membership in. He is a member of the American Association for the Advancement of Science and has served on the research committee of the Industrial Research Institute. He is a former Chairman of the Antitrust Committee and member of the Board of Managers (American Patent Law Association), ex-member of the Board of Directors and Vice-President (United States Trademark Association), the founding Chairman of the Patent, Trademark and Copyright Section (Virginia State Bar), and former Chairman of Patent Division and ex-Secretary and Councilman of Patent, Trademark and Copyright Section (American Bar Association). Presently, he is Chairman of the Publications Committee and Editor, Patent, Trademark and Copyright section of the ABA Journal.

Dr. Jackson's notable contributions to the Virginia Academy of Science have been through his capacities as ex-Chairman of the Engineering Section, Councilman, and a continuing member of the Finance and Endowment Committee.

Walter B. Olstad (*engineering sciences*) received his B.S. (1954) in mechanical engineering from Brown University, M.S. (1958) in aerospace engineering from VPI & SU, and Ph.D. (1967) in applied mathematics from Harvard University. He joined NACA/NASA Langley Research Center in 1954 as an aeronautical engineer in the 8-ft transonic tunnel branch, and has progressed through heading gas physics section and advanced analysis branch to his present position as Chief of the Space Systems Division.

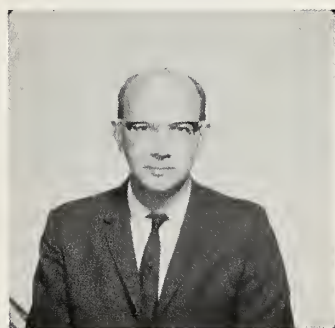
Dr. Olstad is an international authority in the fields of aero-





thermodynamics and radiative heat transfer. He has made major research contributions in the areas of experimental and theoretical transonic aerodynamics, reentry configurations, planetary entry aerothermodynamics and radiative heat transfer. He has taught advanced courses for the University of Virginia, VPI & SU, and George Washington University.

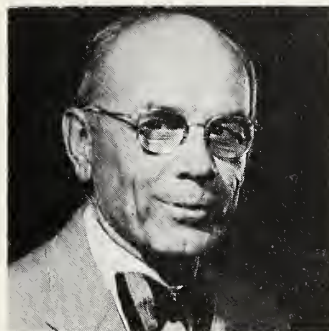
Dr. Olstad has played a very active role in the AIAA technical committees on fluid mechanics and space systems, and as an Associate Editor of the AIAA Journal. At the present time, he is the Technical Program Chairman of the AIAA 12th Thermophysics Conference and acting Editor of the Journal of Spacecraft and Rockets.



Charles H. O'Neal (*medical sciences*) received his B.S. (1957) degree in chemistry from Georgia Institute of Technology, and Ph.D. (1963) in biochemistry from Emory University. His professional experience includes his being the head of technical instruction branch at U.S. Army Chemical Corps' Chemical Replacement Center, Atlanta, Ga.; scientist at National Institute of Health's Laboratory of Biochemical Genetics, Bethesda, Md.; and a visiting scientist at Cambridge University's Laboratory of Molecular Biology. He joined the faculty of the Rockefeller University in 1965, and since 1968, he has been an associate professor of biophysics at the Medical College of Virginia, Virginia Commonwealth University.

Dr. O'Neal is a *fellow* of the American Institute of Chemistry. He holds memberships in the American Chemical Society, Biophysical Societies of the USA and UK, American Association for the Advancement of Science, Sigma Xi and Virginia Academy of Science. He is currently President of Virginia Institute of Chemists, and past President of the MCV-VCU chapter of Sigma Xi. He has served the Academy notably as past Editor of the Virginia Journal of Science.

Russell J. Rowlett, Jr. (*chemical sciences*) received his B.S. (1941), M.S. (1941) and Ph.D. (1945) degrees in chemistry from the University of Virginia. He started his professional career as a research chemist with E.I. du Pont de Nemours and Company, Inc., and joined the staffs of the Chemical Abstracts Service and Virginia Chemical Corporation in 1947 and 1952, respectively. He rose to the position of the Director of Research and Development at VCC. During 1960-67, he served the Virginia Institute of Scientific Research as the Assistant Director. He has been the Editor of the Chemical Abstracts Service since 1967.



Dr. Rowlett is a *fellow* of the American Association for the Advancement of Science, the American Society for Information Service, the Society of Sigma Xi, the Alpha Chi Sigma, and the Ohio Academy of Science. He holds membership in the American Chemical Society and was Chairman of the 1974 Gordon Research Conference on Scientific Information Problems in Research. He is a member of the Board of Directors and President of the National Federation of Abstracting and Indexing Services, the Columbus Center for Science and Industry, and the Board of Trustees of Columbus Goodwill Industries.

Dr. Rowlett is the author of some 40 papers in synthetic organic chemistry, antimalarial drugs, research administration, chemical nomenclature and information science. He has been the recipient of a Presidential citation for research during World War II, and the Board of Visitors Research Award of the University of Virginia. He has served the Virginia Academy of Science with devotion. The Academy honored him with the Ivy F. Lewis Distinguished Service Award in 1967 and elected him an Academy Fellow in 1971.



Paul B. Siegel (*agricultural and poultry sciences*) was born on November 19, 1932 in Hartford, Connecticut. He received his B.S. (1953) from University of Connecticut, and M.S. (1954) and Ph.D. (1957) from Kansas State University. Since 1957, he has been on the faculty at VPI & SU where he holds the rank of University Distinguished Professor. Dr. Siegel's instructional and research interests are in the areas of genetics and animal behavior with primary emphasis on chickens and quail.

Dr. Siegel is a past President of the Poultry Science Association and Animal Behavior Society. At present, he is a member of the Executive Committee of the American Institute of Biological Sciences. He is a 1974 recipient of the CPC International Award for Poultry Science.

Dr. Siegel serves on the editorial board of several journals. He is an ex-Editor of the Virginia Journal of Science (1962-66) and past President of the Virginia Academy of Science (1968). In recognition of his distinguished services, the Academy elected him a *fellow* in 1972.

Joanne Simpson (*environmental sciences*) was born in Boston, Mass. on March 23, 1923. She received her B.S. (1943), M.S. (1945), and Ph.D. (1949) in meteorology from the University of Chicago. She has held faculty positions at the Illinois Institute of Technology, Woods-Hole Oceanographic Institution-MIT, and





the Universities of Chicago, California at Los Angeles, Miami, and Oregon. At the University of Virginia, she is the William W. Corcoran Professor of environmental sciences and a member of the Center for Advanced Studies. She was also the Director of NOAA's Experimental Meteorology Laboratory in Coral Gables, Fla.

Dr. Simpson has published some 90 articles, several of which are book-length. Her principal research interests are weather modification and air-sea interaction. She has served on several national and internal committees and panels which include the following: American Meteorological Society/American Geophysical Union panel on tropical meteorology and air-sea interaction (1961-63), project Stormfury on hurricane modification advisory panel (1962-66), National Academy of Science panels on weather modification (1964), national hail research experiment advisory panel (1974-76), U.S. GATE project (1975- ), National Science Foundation advisory panels of the atmospheric sciences (1973- ) and RANN (1975- ) divisions, U.S. Army scientific advisory panel (1975- ), Illinois State Water Survey advisory panel (1975- ), Food and Agricultural Organization of the U.N. (1975- ), and the U.S. national committee of the International Union of Geodesy and Geophysics (1975- ).

Dr. Simpson is a *fellow* of the American Meteorological Society, and holds memberships in Phi Beta Kappa, Royal Meteorological Society and Sigma Xi. She is a contributing member of the Virginia Academy of Science.

In recognition of her research contributions and distinguished service to the scientific community, Dr. Simpson has received several honors which include the Guggenheim Fellowship (1954), American Meteorological Society's Meisinger Award (1962), Distinguished Authorship Award (1969), U.S. Department of Commerce Silver Medal (1967) and Gold Medal (1972), and University of Chicago Alumni Association's Professional Achievement Award (1975). She was named the Woman of the Year by the LA Times (1962) and Woman of the Year in Science by Ladies Home Journal in 1975, 1976, and 1977. She gave the *Frontiers in Environmental Sciences Lecture* at the first regular program of the Environmental Sciences Section at the 53rd annual meeting of the VAS held in Harrisonburg, Va.

Dr. Simpson is serving a second three-year term as the Associate Editor of Reviews in Geophysics and Space Physics.

David A. West (*life sciences*) was born in Beirut, Lebanon. He received his B.S. and Ph.D. (1960) degrees in Zoology from Cornell University, and pursued post-doctoral studies for two years at Liverpool University. He joined the faculty at Virginia Polytechnic Institute and State University in 1962 where he is an associate professor of biology. He has authored several papers, and his current special research interest lies in the important field of ecological genetics.

PHOTO NOT AVAILABLE

Dr. West is a dedicated member of the Virginia Academy of Science. He has very ably served the Academy as the immediate past Editor of the Virginia Journal of Science.



### HARSHBARGER WINS AAS' DISTINGUISHED SERVICE AWARD

The Association of Academies of Science honored Boyd Harshbarger, a distinguished teacher and scholar of statistics at VPI & SU and the archivist of the Virginia Academy of Science with one of its two distinguished service awards for 1977. The other award went to Robert C. Miller of California. Harshbarger was the president of the Association in 1950.

Harshbarger has been a vigorous leader in the Virginia Academy of Science. He was the founder and editor-in-chief of the Virginia Journal of Science, and served as the VAS' president in 1949-50. He won the J. Shelton Horsley Research award in 1946, and was honored with the Ivey F. Lewis Distinguished Service Award in 1966. He was elected an Academy Fellow in 1970.

## IN MEMORIAM

### WILBUR HARNSBERGER

Wilbur T. Harnsberger, Jr., the founder of the Geology department at Madison College in 1956 and the department head since that time, died of apparent heart attack at age 56. His prior association was with the Virginia Geological Survey.

Harnsberger was born in Danville. He received

his B.A. (1948) and M.S. (1950) degrees from the University of Virginia. His research publications were in the field of economic and fuel geology. He won awards from Sigma Xi, Sigma Gamma Epsilon, Phi Delta Kappa and Kappa Delta Pi. In recognition of his dedicated services, the Virginia Academy of Science elected him a fellow in 1971.

# PAPERS TO APPEAR IN THE FALL 1977 ISSUE

## ARTICLES

Photoelectrolytic Decomposition of Water by Solar Energy—A Possible Source of Fuel. *Aaron Wold*, Brown University, Providence, Rhode Island

Depth-Dose Relations for Heavy Ion Beams. *J. W. Wilson*, NASA Langley Research Center, Hampton, Virginia

## NOTES

Distribution and Habitat of the Cotton Rat (*Sigmodon hispidus*) in Central Virginia. *John F. Pagels*, Virginia Commonwealth University, Richmond, Virginia

Polydactyly in *Myocastor Coypus*. *Gale R. Willner* and *Joseph A. Chapman*, Center for Environmental and Estuarine Studies, University of Maryland, Frostburg, Maryland

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Articles (other than abstracts, correspondence and comments, and news and notes) should be sent to the Editor, Dr. Kuldip P. Chopra, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA. 23508. Manuscripts dealing with science and society, history of science and technology, correspondence, and news and notes should be addressed to the Associate Editor, Dr. Michael N. Bishara, Engineering Division, Southwest Community College, Richlands, VA. 24641. Short notes (not exceeding eight double-spaced typed pages, 2500 words or equivalent including illustrations) may be sent to the Editor or one of the members of the Editorial Board. Proofs, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

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4. Text. The text should be divided into sections and subsections (if necessary), each with a separate heading. Section headings should be typed on a separate line and centered. Subsections should be set into the text and underlined. Sections and subsections should **not** be in capitals.
5. Acknowledgements.
6. References. Literature cited in the text should follow the name- and year-format: Birkhoff and Zarantonello (1957), or (Simpson and Dennis, 1974). List of references, in the section so titled, should be arranged alphabetically on a separate page. Abbreviations for journal articles should conform to the List of Periodicals in the Chemical Abstracts Service Source Index, the American Institute of Physics Style Manual or the Bibliographic Guide for Editors and Writers.

Each reference should be complete and in the following form: author(s), year within parentheses, title of article, title of journal (abbreviated and underlined or

typed in script), volume number (underline with wavy line), and pages. For a book: author(s), year, title of book (underlined or typed in script), page, publisher and city of publication. Examples:

Birkhoff, G. and Zarantonello, E. H. (1957): Jets, Wakes and Cavities, pp. 280-293. Academic Press, New York.

Chopra, K. P. (1961): Interactions of Rapidly Moving Objects in Terrestrial Atmosphere. *Rev. Mod. Phys.* **33**, 153-172.

Simpson, J. and Dennis, A. S. (1974): Cumulus clouds and their Modification. In *Weather Modification* (W. N. Hess, ed.), Chap. 6, pp. 229-280, Wiley, New York.

**References to project or company reports, technical memoranda and personal communications are not permissible**, except as footnotes under exceptional situations. Footnotes in the text should be numbered serially throughout a manuscript.

7. Illustrations. Glossy prints are preferred to oversized original drawings. The lettering on the latter should be such that the smallest character after reduction is about 1.5 mm high. Each figure should be mentioned specifically in the text. Figure number and legend will be set in type and **must not** be part of the drawing. All legends should be typed together, and figures identified by author's name and figure number in pencil on the back.

8. Tables. Each table should be numbered in Roman numerals, carry a title which is complete and intelligible, should have clear and concise column headings and should be typed on a separate page. Indicate units where needed. Footnotes should be designed by a superior lower case letter (a, b, c, etc.) and should begin anew for each table.

9. Mathematical Symbols and Formulas. Formulas should be composed carefully for utmost clarity and economy. Equations should be identified with numbers within parenthesis at the right-hand margin. The word equation(s) in the text should be abbreviated Eq(s). Radical sign should be avoided; to indicate roots, use a fractional exponent. For fractions, use solidus (/), the negative exponent or the division sign. Examples:  $a/b^{1/2}$ , or  $ab^{-1/2}$ , or  $a \div b^{1/2}$ . Avoid double-line fractions, double subscriptions or superscripts, and indicate vectors or matrices by placing a wavy line under the symbol. When the exponent  $e$  is modified by a complicated exponent, use the symbol  $\exp$ . Use of International System of Units is preferred. Explain unusual symbols with marginal notes in pencil.

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# VIRGINIA JOURNAL OF SCIENCE

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VOL. 28, NO. 2

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# THE VIRGINIA JOURNAL OF SCIENCE

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# VIRGINIA ACADEMY OF SCIENCE

## FIFTY-FIFTH ANNUAL MEETING, PETERSBURG

### MAY 10-13, 1977

#### SUMMARY OF ACADEMY CONFERENCE AND ACADEMY ASSEMBLY AND NOTES FROM COUNCIL MEETING

May 11, 1977

The Council of the Virginia Academy of Science met on Wednesday, May 11, 1977 in Hunter-McDaniel 103 at Virginia State College in Petersburg, Virginia. President W. Allan Powell called the meeting to order at 2:15 p.m. In attendance were K. P. Bo-  
vard, Blanton M. Bruner, Arthur Burke, D. Rae Carpenter, Jr., Kuldip P. Chopra, Virginia C. Ellett, Franklin F. Flint, Billy J. Gilpin, Edward S. Harlow, Boyd Harshbarger, Ralph A. Lowry, Peter Mazzeo, W. Allan Powell, Stanley Ragone, Ertle Thompson, Edward F. Turner, Jr., Dale V. Ulrich, Donna Ware, Warwick R. West, Jr., John E. White, John H. Wise, B. R. Woodson, and J. S. Gillespie.

#### PRESIDENT'S REPORT

##### *Business Manager, VJS*

Dr. Powell announced that Dr. Auzville Jackson, Jr., who is a member of the Finance and Endowment Committee and Assistant Vice-President of Technology and Chief Patent Counsel for Robertshaw Controls Company, has agreed to serve as Business Manager for the Virginia Journal of Science.

##### *Editorial Board*

Dr. Powell noted that there has not been an Editorial Board for the Virginia Journal of Science for some time. At the last meeting of the Council, Dr. Kuldip Chopra, Editor, voiced his desire to have such a board. The VAS Council concurred with Dr. Chopra's recommendation, and the following scientists have agreed to serve on the Editorial Board:

Dr. Walter Olstad, Chief, Space Systems Division, NASA Langley Research Center, and Acting Editor, Journal of Spacecraft and Rockets (AIAA)

Dr. Charles O'Neal, Department of Biophysics, MCV/VCU and ex-Editor of VJS

Dr. Russell J. Rowlett, Jr., Editor, Chemical Abstracts Service (ACS) and fellow of the Academy

Dr. Paul B. Siegel, University Distinguished Professor, VPI & SU, ex-Editor of VJS and past president of the Academy

Dr. Joanne Simpson, William W. Corcoran Professor of Environmental Science, U. VA., and Associate Editor, Reviews of Geophysics and Space Physics (AGU)

Dr. David West, VPI & SU, retiring Editor of VJS

All of these members have extensive experience with

publications. In addition, Dr. Michael Bishara of the Southwest Community College will play an active role as the Associate Editor for Science and Society.

##### *Section Editors*

The various VAS sections have been urged to elect or designate section editors. The editor will work closely with the section editors who were scheduled to meet at 5:00 p.m. on Thursday in Hunter-McDaniel, Room 105.

##### *Production Editors*

Mr. Ernest Maygarden and Ms. Alarie Tennille of the ODU Research Foundation have agreed to serve as production editors.

##### *1978 Meeting*

The 1978 annual meeting will be held May 9-12 at Virginia Polytechnic Institute and State University in Blacksburg, Virginia. There was some discussion about holding the meeting one week earlier to avail of better facilities and student help with projection equipment.

##### *1979 Meeting*

Dr. Powell announced that the final commitments have been made to hold the 1979 annual meeting at the University of Richmond. Dr. Frank Leftwich of the Department of Biology at the University of Richmond shall serve as the Chairman of the Local Arrangements Committee for the meeting. The University administration has approved this appointment.

#### PRESIDENT ELECT'S REPORT

Dr. Lowry reminded the Council that Dr. George Sands would be presenting a special lecture on the Viking mission as part of the Academy's recognition of that program. Dr. Powell encouraged everyone to attend.

Dr. Lowry reminded the Council that the new section chairmen and secretaries would meet May 12 at 5:00 p.m.

#### REPORT OF CHAIRMAN, LOCAL ARRANGEMENTS COMMITTEE

Dr. Bernard R. Woodson, Chairman of the 1977 Local Arrangements Committee, welcomed everyone to the 1977 annual meeting. Dr. Woodson commended the Committee for a fine job.



Dr. Woodson reported that the Virginia Cultural Laureate Society is seeking a nomination for laureate to be awarded at the banquet this fall (October, 1977). The Governor and Inge Rice, wife of the former ambassador Walter Rice, will attend the ceremony.

## REPORT OF THE EDITOR, VIRGINIA JOURNAL OF SCIENCE

Dr. K. P. Chopra, Editor, reported that Dr. David West had sent the Fall 1976 issue to the printer and that he was then working on the Winter 1976 issue. Dr. Chopra was working on the Spring issue (Vol. 28, No. 1) and was awaiting editorial and news features and copy-editing prior to sending the material to the printer. Since the last Council meeting, the Editor had received eight papers: botany (1), environmental sciences (1), environmental health (1), life sciences (1), photochemistry/nuclear energy (4). Dr. Chopra said that he had encouraged sections to elect their editors with whom he planned to meet at 5:00 p.m. the next day. Old Dominion University has provided logistics support through its personnel and other resources for the production of the Journal.

## REPORT OF THE DIRECTOR, VISITING SCIENTISTS' PROGRAM

Dr. Dale V. Ulrich, Director of the Visiting Scientists' program, reported that 1976-77 has been a good year for the program. By mailing speakers' lists in August, teachers were able to arrange for speakers for two additional months, early in the fall. Forty-seven visits were reported during the year which resulted in a student audience of 2760.

Dr. Ulrich had requested reports from each host of a visiting scientist. Following were typical of the comments he received from them:

"He gave a tremendous presentation that kept the attention of our students from the time he started until he uttered his last word."

"We have used the Visiting Scientists' program before, and again we would like to express how excellent it is and how fortunate we are to have access to six colleges within a 50-mile radius."

"We thoroughly enjoyed the presentation and appreciate the service of the VAS."

"He was fabulous! He brought with him an enormous ball and stick model of DNA as well as several small models of individual nucleotides. He spoke to about 100 students, giving his lecture three times."

"On March 4, he attended our club meeting and gave an excellent talk on fluorescence. It lends merit to your fine program to have such capable and enthusiastic participants."

Dr. Ulrich reported that Dr. Gerald R. Taylor, Jr., a physics professor at Madison College, has assumed the responsibilities of the program director. Dr. Taylor has gained permission of the State Department of Education to conduct the program in public schools, and an appropriate memorandum has been mailed from Richmond to all Division Superintendents. Dr. Taylor has also written to the various college presidents inviting their support of the program and seek-

ing their recommendations of speakers and topics for inclusion in the 1977 Speakers' list.

The Visiting Scientists' program is in capable hands and should be expected to make fine progress under Dr. Taylor's leadership. President Powell thanked Dr. Ulrich for a fine job as Director of the Visiting Scientists' program for 1976-77.

## REPORTS OF STANDING COMMITTEES

### *Nominating Committee*

Dr. Stanley Ragone, Chairman for the VAS Nominating Committee, reported that a slate of officers for nominations at the Academy Conference to be voted upon by the membership was prepared in accordance with the directions and wishes of the Council, as expressed in the November 1976 meeting. Included in the Call for Papers, mailed in December 1976, was a request for suggestions for nominations for President-Elect, Secretary, and Treasurer to reach the Chairman of the Nominating Committee by February 25, 1977. Sixteen members responded to this request. The Council members made their own suggestions. Based on these suggestions, the Nominating Committee developed a slate of officers. On March 25, 1977, these nominations for the Academy Officers, including a brief biographical sketch of each nominee, were mailed to the membership along with the information regarding the annual meeting. Ballots were prepared for use on May 12. It was suggested that the President designate a teller. Dr. Powell said that the votes would be tallied and announced at the Academy Conference. Dr. Bovard commended the Nominating Committee for a fine job.

### *Finance and Endowment Committee*

Dr. Rae Carpenter, Jr., Chairman of the Committee, reported that he had received very little response to his letter asking Section Secretaries how the Academy funds should be spent. He planned to get more feedback at the President-Elect's meeting with Section Chairmen and Secretaries.

### *Fund-Raising Committee*

Chairman J. S. Gillespie reported that no money had been raised to date. Dr. Powell noted that there had not been an active fund-raising committee for some years.

### *Junior Academy of Science Committee*

Dr. John L. Hess, Chairman, reported that 380 students had registered for the meeting in comparison with 350 last year. During the academic year, 105 schools were affiliated with the Academy. Dr. Hess noted that 173 papers were selected out of 332 submitted this year; 168 of these were to be presented that day. Science Clubs from Pulaski and Waynesboro high schools had presented written reports to the VJAS this year. Dr. Hess noted that for the past three years there has been an overlap between the VAS meeting and the National Science Fair. For the next 10 years, the National Science Fair will be held during the second week in May and will continue to remain in conflict with the VAS annual meetings. A



paper by the VJAS was presented at the AAAS annual meeting.

#### *Membership Meeting*

Dr. Warwick R. West, Jr., Chairman, reported on the actions taken by the Committee since March 12, 1977. Letters were sent to all Section Chairmen requesting their support in building the membership. The benefits of the membership in the Academy and the role of the VJS were emphasized in that letter. The overall result was a gain of 61 new members. Dr. Harold M. Bell of the Department of Chemistry at VPI & SU was responsible for 17 new members.

Membership as of January 1, 1977 was 1426, and since that date there had been 12 resignations. An addition of 61 new members to the remaining active members placed the total current membership at 1475.

Fifty dollars of the Academy funds were received from Dr. Addison D. Campbell for use by the Committee. To date, only \$11.16 had been spent for postage related to correspondence and mailing of brochures and membership application forms.

#### *Publications Committee*

Dr. John H. Wise, Chairman, reported that the major activity of the Publications Committee for 1976-77 has been the reorganization of the Virginia Journal of Science. Dr. Chopra, who replaced Dr. West as Editor of the Journal, has undertaken a vigorous program with the support of the Publications Committee.

#### *Research Committee*

Dr. Powell reported for Dr. Paul Osborne, Chairman who could not be present, that there was still some unspent money in the Research Fund. A grant of \$300 was recently awarded to Dr. Stipes at VPI & SU.

#### *Trust Committee*

Edward S. Harlow, Chairman, presented the following report. As instructed by the Council, the Old Agency Trust Account was closed and the assets transferred to the First and Merchants Balanced Trust Fund in accordance with the agreement entered on November 23, 1976. This changeover is advantageous for reasons of increased income and value appreciation and lower administrative costs (ca \$300). A letter dated April 15, 1977 from Mr. John T. King, the Trust Officer at First and Merchants National Bank, indicates the value of \$45,898.71 for the VAS Trust on April 1, 1977. Additional \$1,348.17 was being held in the income account.

#### *Virginia Flora Committee*

Dr. Peter M. Mazzeo, Chairman, reported that \$300 allocated to the Flora Committee has been dispersed, and many botanists were doing research in the field. The Flora project would be reviewed at the Committee meeting the next day. Dr. Powell noted that he and Dr. Rae Carpenter were looking into the plans for and status of publication of the Atlas of Virginia Flora. This matter would also be discussed at the Flora Committee meeting.

## REPORTS OF AD HOC COMMITTEES

#### *Archives*

Boyd Harshbarger, Archivist, reported that more than 75 percent of the Academy material has been catalogued with a card which lists author and subject matter and is now contained in the filing cases or in cabinets. Any member can request and receive material which pertains to a particular subject. VPI & SU has assigned the Academy a large carrel, and it is designated the Virginia Academy. Dr. Harshbarger requested reports distributed at today's meeting for filing with the VAS materials.

#### *Science Education*

Dr. Arthur Burke and Virginia C. Ellett, Cochairmen, reported that the Committee has assisted Mr. Frank Kiser and the State Department of Education in sponsoring the annual Fall State Teachers' Conference and Workshops. Mr. Kiser and participants in the 1976 Conference felt that the Committee's co-sponsorship was helpful, and Mr. Kiser expressed his firm conviction that the Conference and Workshops need the continued support of the Virginia Academy of Science.

For the 1977 Conference and Workshops to be held in Fredericksburg, Virginia on October 7 and 8, the Committee is endeavoring to bring a series of lectures on earth science and has arranged a guided tour of the US Geomagnetic Center at Corbin, VA. At the invitation of the State Department of Education and the U.VA. School of Education, the Committee members attended a meeting regarding coordination of science-education in Virginia held in Charlottesville, VA.

#### *Science Museum*

Dale Ulrich reported that his response to A. B. Niemeyer's request has been that it is up to the individuals in the Visiting Scientists' program to volunteer to give public lectures at the Virginia Museum. A number of projects are underway, and a number of donations are available. An architect is now working on the development of the Union Station as a science museum. Dr. Powell reported that he had appointed a planning committee to study the crystallographic exhibit for the Science Museum. Stan Ragone reported that the Science Museum Committee would be meeting on Thursday.

#### *Science Advisory*

Dr. Ertle Thompson reported that the Committee has been working with the Governor's Office, the Water Quality Board, the Air Pollution Board, and the Kepone Task Force. The Governors' Conference on Science and Technology, originally scheduled to be held in April in Atlanta, GA., had been postponed until May 19, 1977. Among the topics to have been discussed at the Conference are (a) conversion to metric measurements, (b) transportation, (c) support by NSF of science activities at the state levels, and (d) science concerns and initiative of President Carter.

Dr. Thompson reported on the status of the proposal to establish the advisory system as a standing committee of the Academy. The *ad hoc* committee



has been active for the past three years, and its recognition as a useful resource has been increasing. It is recommended that this standing committee, if adopted, consist of the following:

1. a chairman appointed by the President of the Academy to serve a three-year term
2. three members at large, appointed by the President
3. the past President of the Academy
4. the past Chairmen of each of the sections of the Academy
5. one member elected at large from each section of the Academy

This would be a large committee; therefore, it is recommended that the standing committee, if implemented, have a smaller steering committee consisting of the Chairman, the past President of the Academy, and three members elected from the membership of the Advisory Committee.

Dr. Arthur Burke moved that the report of the *ad hoc* committee to plan for a science advisory system in Virginia be accepted in principle. The motion was seconded and adopted unanimously. Dr. Art Burke moved that the Constitutions and Bylaws Committee be instructed by Council to study and develop the necessary amendments to institute a standing committee charged with serving as a science advisory resource for state and local governmental agencies. The motion was seconded by Dr. Ken Bovard and adopted unanimously by Council.

#### *Local Arrangements for 1978*

Dr. Donald Cochran, VPI & SU, reviewed planning for the 1978 VAS Meeting to be held in Blacksburg, Virginia. The main sites of the 1978 meeting will be the VPI & SU Continuing Education Center and the Squires Student Center. These two buildings are across the street from each other. There are many private motels and restaurants in the vicinity. The dates of the 1978 meeting are May 9-12.

### REPORTS OF SECTIONS

Dr. Trelawny noted that the national meeting of the American Society for Microbiology frequently conflicts with the annual meeting of the Academy. Dr. Powell noted that the Long-Range Planning Committee is studying the recurring problem of the time of the VAS meeting. There was a thorough discussion of changing university calendars and other meetings normally scheduled in the spring. Dr. Bishara suggested that it may be desirable to hold some of the Academy meetings at convention centers rather than on college campuses.

Dr. Burke moved that President-elect Lowry attempt to identify a more suitable meeting time after consulting with the Long-Range Planning Committee, university officials and other sources. The motion was seconded and passed unanimously.

Dr. Powell presented the report of the Environmental Sciences Section for Dr. Chopra who was unable to report since he was presenting a paper in the Education Section. Dr. Powell reported that Dr. Roger Anderson, Section Chairman, had moved to Florida. Sixteen contributed papers, a possible VJAS

Award paper, and a symposium on Virginia Fisheries were planned for this meeting. No announcement calling for entries to the Roscoe Hughes Graduate Paper Award was made. Therefore, this award would not be made this year. However, the Junior paper award would be made in the VJAS Awards session on Thursday morning. After some introductory remarks by Dr. Chopra, Mrs. Betty Hughes should present the Certificate and an appropriate check to the winner. The slate of officers nominated for the next year consisted of the following:

Chairman: Dr. Eugene Silberhorn, VIMS  
 Vice-Chairman: Mr. Ronald Schmied, VIMS  
 Secretary: Mr. Gilmore Trafford, NASA-WFC

Editor: Dr. Maurice Pritchard, ODU

Dr. Chopra shall continue to represent the Environmental Sciences Section on the VAS Council until his three-year term expires in 1978.

### OLD BUSINESS

The proposed guidelines for financing awards were discussed. This item had been tabled at the March meeting. The recommendations included the following: (a) that the sections generate cash awards financed by dues collected within the section, provided the awards committee is notified prior to the call-for-papers; and (b) that awards requiring external funding would conform to the following procedures—communicating to the awards committee, through the president, the criteria, method of selection, and the proposed source of funding; if approved by the awards committee, the feasibility and desirability of the proposal would be reviewed by the VAS Executive Committee. Dr. Flint commented that the distinction between internal and external funding was not clear to all. Internal funding refers to moneys generated by section dues or budgeted by the Academy. Dr. Art Burke proposed that President-elect Lowry discuss this issue with the section chairmen at his meeting with them. Dr. Carpenter noted that the sections' representatives to Council should discuss this issue at their section business meetings. Dr. Flint indicated that the Long-Range Planning Committee had prepared a recommendation based upon the best evaluation of the opinions, views, and information available to it. Dr. Rae Carpenter reviewed the problem of special external fund raising to support awards, particularly of the VJAS.

Dr. Trelawny moved and Dr. Art Burke seconded a motion that the Long-Range Planning Committee be directed by Council to condense its March recommendation into as few words as possible with supplementary documents to qualify such things as internal and external requested funds.

### NEW BUSINESS

#### *Science Youth Camp*

Dr. Powell reported that he had received a letter from Frank Kiser pertaining to the Science Youth Camp. As this is to be a 1978 program, he would like to have someone representing VAS to serve on the committee which will meet during the last week of

February and assist in the selection process. Dr. Boyd Harshbarger moved that the President appoint such a person to prepare the material for Mr. Kiser and to serve on the selection committee. The motion was seconded and approved unanimously by Council.

#### *1980 Annual Meeting*

Dr. Powell reported that he had received an official invitation from the University of Virginia to hold the 1980 VAS annual meeting in Charlottesville, Virginia. In the past, Council has accepted these invitations on a tentative basis and has delayed final acceptance pending a report from the university concerning the available facilities. Rae Carpenter said that the Council should, in his opinion, do an inspection of the facilities before making even a tentative commitment. Dr. Burke made a motion that the Council acknowledge receipt of the letter from U.V.A. and respond that Council will discuss the dates of the meeting and facilities available. Rae Carpenter seconded the motion which was passed by Council.

### ADJOURNMENT

Boyd Harshbarger made a motion that the meeting be adjourned. There being no further business, the meeting was adjourned at 4:55 p.m.

### ACADEMY CONFERENCE

May 12, 1977

President Allan Powell convened the 1977 Virginia Academy of Science Conference in Hunter-McDaniel Hall, Virginia State College, Petersburg, VA at 11:35 a.m. on May 12, 1977. Over 70 Members were present.

On behalf of the Nominating Committee, Stanley Ragone placed in nomination two candidates for each elective office of the Academy for the year 1977-78:

President Elect: Dr. Ertle Thompson, New School of Education, U. VA.  
Dr. Dale V. Ulrich, Bridgewater College

Secretary: Dr. Gaylen Bradley, Virginia Commonwealth University  
Dr. Harold G. Marshall, Old Dominion University

Treasurer: Mrs. Vera B. Remsburg, John S. Battle High School  
Dr. Donna Ware, College of William & Mary

There were no nominations from the floor, a motion to close nominations was approved, and the voting was conducted by written ballot. The following persons were declared the new officers:

President: Dr. Ralph A. Lowry, University of Virginia

President-elect: Dr. Dale Ulrich

Secretary: Dr. Gaylen Bradley

Treasurer: Mrs. Vera B. Remsburg

#### *Virginia Junior Academy of Science*

Dr. John L. Hess, Director of the Virginia Junior Academy of Science, reported on the 1977 Annual meeting of the VJAS. A total of 332 papers were received for consideration of which 173 were selected for presentation, and 168 of these were actually presented. The remaining 5 papers were presented at the International Science Fair in Cleveland, Ohio—a meeting that conflicted with the VJAS meeting.

There were 105 science clubs affiliated with VJAS in 1976-77, and the registered attendance at the meeting was 496. Science club reports were presented by Pulaski High School and Waynesboro High School. The Pulaski High School club was recognized as the Outstanding Science Club.

Lee Anthony, who directed the VJAS from 1972 to 1975, was selected for the Distinguished Service Award. Mrs. Roscoe Hughes was presented with a commemorative copy of the Proceedings on the 1976 VJAS meeting. Mrs. Hughes then presented the VAS Environmental Sciences Section's Roscoe Hughes Junior Paper Award to Jeri L. Jack of Handley High School, Winchester.

The Virginia Junior Academy of Science held a successful scientific program on May 11, 1977. The following papers were recognized:

#### Behavior Science Section

- 1st Marvin H. Warren, Manor High School, Portsmouth. An investigation of the relationship of photoperiodism to the activity of mice.
- 2nd Susan D. Rice, Graham High School, Tazewell County. Honesty vs. Grades.
- 3rd Faith M. Larkin, Floyd E. Kellam High School, VA. Beach, Do you Procrastinate?

#### Developmental Biology Section

- 1st Scott W. Nolley, Collegiate Schools, Richmond. A study of the various effects of vitamin E on the fertility of *Drosophila melanogaster*.
- 2nd William R. Christian, Collegiate Schools, Richmond. An investigation into the effects of chemical stimuli on the blood circulation in goldfish,
- 3rd Randolph D. Rogers, Waynesboro High School, Waynesboro. Phototropism in *Colium fragilis*.

#### Molecular Biology Section

- 1st Pamela Kopelove, Churchland High School, Portsmouth. Chemoreception in *Nassarius Obsoletus*: the role of specific stimulatory proteins.
- 2nd George F. Freeman, Poquoson High School, Poquoson. A study of neurite-growth stimulation in CNS neurons by fluorodeoxyuridine.
- 3rd Kathy O. Johnston, Liberty High School, Bedford County. The biochemistry of bread-making.



**Organismic Biology Section**

- 1st Susan O. Hinton, Manor High School, Portsmouth. Mathematical relationships of growth whorls of selected gastropods.
- 2nd Carolyn A. Corcoran, Abingdon High School, Washington County. The effects of fatigue and luminance on binocularity and fusional amplitude.
- 3rd Gregg R. Eure, Pheobus High School, Hampton. The effects of ascorbic acid on the behavior and metabolism of mice.

**Population Biology Section**

- 1st Carol D. Weiseman, McLean High School, Fairfax County. Age and growth analysis of yellow perch in Cardinal Lake.
- 2nd Mark R. Machen, Gunston Junior High School, Arlington Co. Does growing space effect baby guppies?
- 3rd Mark S. Ivanhoe, Roanoke Catholic High School, Diocese of Richmond. Variations in the populations of soil nematodes.

**Chemistry Section**

- 1st Mark R. Jackson, Mechanicsville High School, Newport News. Titrimetric analysis of antacid tablets.
- 2nd Joseph P. Dougherty, McLean High School, Fairfax County. A synthesis and laser decomposition of 1,1 dimethyl -2,2 defluorocyclopropane with some applied analytical methods.
- 3rd William G. Way, John Handley High School, Winchester. A comparative analysis of a gravimetric extraction analysis and an isotopic dilution analysis for the extraction on caffeine from tea.

**Earth Science Section**

- 1st Ernest Wilegg, Floyd E. Kellam High School, Virginia Beach. Temperature inversion vs. air pollution.
- 2nd Terri L. Graves, Churchland High School, Portsmouth. The effect of moisture content on the resistivity of soil samples.
- 3rd Nathaniel G. Robbins, Stratford High School, Arlington County. Using celestial navigation methods to find your position on land.

**Engineering Section**

- 1st Lewis R. Grigg, Floyd E. Kellam High School, VA. Beach. Wing sails vs. cloth sails.
- 2nd Hans C. Tallis, West Springfield High School, Fairfax Co. Computer aided lens design.
- 3rd Charles M. Gills, Liberty High School, Bedford County. The solar heated home: a statistical analysis.

**Environmental Science Section**

- 1st Jeri L. Jack, Handley High School, Winchester. The effect of topical acne agents on staphylococci.
- 2nd Rory F. Heffernan, Liberty High School, Bedford County. The effect of DDT on the pea.
- 3rd Webster C. Houlgrave, Collegiate Schools, Richmond. Pyramid power.

**Mathematics Section**

- 1st Glenn C. Poole, Annandale High School, Fairfax County. The theory and implementation of a semantic processor.
- 2nd Stephen J. Jacobson, Norfolk Academy, Norfolk. Pi—some of its history and properties.
- 3rd Sara Miron, Gunston Junior High School, Arlington County. Lucky numbers in sets of multiples.

**Physics Section**

- 1st Vincent E. Hillery, John Randolph Tucker High School, Henrico County. A demonstration of the nonlinear transmission of sound in air and its characteristic behavior.
- 2nd Bruce M. Reynolds, West Springfield High School, Fairfax County. Analysis of data describing gamma radiation production from positronium decay in various solids.
- 3rd James F. Elfers, Stratford Junior High School, Arlington County. The bulbous bow on a sailboat.

Vincent E. Hillery was the recipient of the *Russel J. Rowlett Best Research Paper of the Year Award*.

Honorable mentions were conferred upon Joni Jay Fink, James W. Lynch, Jr., H. Walker Garrett III, Marta E. Acha, Bernard F. Mimms, Carlton R. Reid, Elizabeth C. Scott, Ann L. Hoganson, Mark R. Boyes, Laurinda Lee, Tedd J. Winter, Rodney A. Weems, Teresa D. Collins, Robert A. Canfield, Pamela K. Hannaman, Glenda K. Whitaker, Leonard Kepler Sweeney, Cheryl A. Orange, Michael A. Beammer, Peter F. Gillette, Douglas A. Burton, Laura N. Nakatsuka, Joan M. Baumann, Richard L. Herwig, Max K. Cannon, and Richard L. Cimerman.

**Finance and Endowment Committee**

Dr. Rae Carpenter presented a summary of receipts and disbursements of the period 1968-76. In his discussion, Dr. Carpenter noted that membership has been declining and has resulted in declining revenues from dues. Approximately one third of the VAS income is devoted to the Virginia Journal of Science. The VAS, through its Research Committee, makes awards totaling about \$2,000 as grants-in-aid of research. Dr. Carpenter called upon the membership to provide guidance to the VAS Council on existing and new programs.

**Membership Committee**

Dr. Rick West reported for the Membership Committee that the current membership totals 1475. He

called upon the membership to join hands with the Committee in encouraging colleagues to join the VAS.

#### *Editorship of Virginia Journal of Science*

President Allan Powell announced that Dr. Kuldip P. Chopra is the new editor of the Virginia Journal of Science. The President also announced that a business manager for the VJS has been selected.

Dr. Chopra indicated that in addition to providing residence to the Virginia Journal of Science, Old Dominion University has committed personnel, library, editorial and production support for the Journal. He added that he expects that the Journal shall soon be back on its regular schedule.

Dr. Chopra has organized a scientific and editorial review panel that will enhance the quality and prestige of the Journal. The editorial board includes Dr. Walter Olstad (NASA-LaRC), Dr. Charles O'Neal (MCV-VCU), Dr. Russell Rowlett (Chemical Abstracts Service), Dr. Paul Siegel (VPI & SU), Dr. Joanne Simpson, (UVA), and Dr. David West (VPI & SU). Dr. Michael N. Bishara (Southwest Community College) is the Associate Editor for Science and Society. Dr. Auzville Jackson, Jr. (Robertshaw Controls Company) is the new business manager. Dr. Chopra urged the sections to elect section editors.

#### *Visiting Scientist Program*

Dr. Dale Ulrich, the immediate past director of the Visiting Scientists' Program, introduced the new director: Dr. Jerry Taylor, professor of physics, Madison College. The Visiting Scientists' Program is completing its twelfth year. The Visiting Scientists' Program now distributes its announcements of available speakers in the fall. The Visiting Scientists have spoken to at least 2,670 students this year. A limited survey indicated that the number of presentations may be five-fold greater than that reported to the director. The program continues to be very successful. President Powell expressed the gratitude of the VAS and the scientific community to Dr. Ulrich for his contributions to the Visiting Scientists' program.

#### *Ad-Hoc Committee to Plan a Science Advisory System*

Dr. Ertle Thompson reported for the Committee that several members of the Academy are currently serving at the invitation of Governor Godwin to advise him on scientific aspects of current environmental problems. Their meetings with the Governor and members of his cabinet have been most encouraging from the standpoint of the Governor's enthusiastic reception and his expressed interest in advisory counsel from the membership of the Virginia Academy of Science in scientific matters. Dr. Thompson recommends that a Science Advisory Committee be constituted as a standing committee of VAS. The *ad hoc* committee has drafted a set of objectives for such a standing committee, should one be established. One of the first activities of the standing committee might be to develop a roster of potential advisors with annotations on their areas of expertise. Imminent problems confronting the scientific community include: conversion to metric units; transportation and

energy; supporting science education; role of the federal government in science initiatives.

#### *Ad-Hoc Committee for Science Education*

Dr. Art Burke reported that the Committee has assisted Mr. Frank Kiser (State Department of Education) in planning the state science teachers' workshop. It was announced that the Academy will co-sponsor the state Science Teachers' Conference to be held in Fredericksburg, Virginia on October 7-8, 1977 at the Sheraton Inn.

#### *Science Museum of Virginia*

Dr. Rae Carpenter reported that the Discovery Room at the Broad Street Station in Richmond is open to the public on weekends. There have been as many as 800 visitors on a weekend.

#### *Fund-Raising Committee*

President Allan Powell announced that he has activated the Fund-Raising Committee in an effort to increase the trust fund. The revenue of the trust fund is used to support research. Dr. Sam Gillespie is the Chairman of the Fund-Raising Committee.

#### *Standing Committee for a Science Advisory System*

The Council has voted to support in principle the concept of a standing committee for a Science Advisory System. The Constitution and Bylaws Committee has been instructed to study and develop proposed amendments to achieve this goal.

#### *Announcement of Election of Fellows*

It was announced that the Awards Committee has recommended and the Council has elected to confer membership as Fellow in the Academy on Dr. Bernard R. Woodson, Dean, Virginia State College. Dr. Woodson is the Chairman, Local Arrangements Committee for the 1977 VAS annual meeting, active in community affairs and is a productive scientific colleague.

The Conference expressed gratitude and thanks to the Local Arrangements Committee, chaired by Dean Bernard Woodson, and to the Virginia State College, its faculty, staff, and students for hosting the 55th Annual Meeting of the Virginia Academy of Science and planning so effectively for it.

The next meeting of the VAS will be held at VPI & SU on May 9-12, 1978.

There being no further business, the Academy Conference was adjourned at 12:40 p.m.

Respectfully recorded:  
S. Gaylen Bradley  
Secretary

### THE ACADEMY ASSEMBLY

May 12, 1977

Following the Annual Banquet, the Virginia Academy of Science Assembly was convened at 8:10 p.m. on May 12, 1977 in the Ramada Inn, Petersburg, Virginia, with President Powell presiding. Dr. Ber-



nard Woodson, Dean of Science and Technology and Dr. Thomas M. Law, President of Virginia State College, greeted the Assembly with a few welcoming remarks.

The following awards were presented:

Academy Fellow:

Bernard Woodson, Virginia State College

J. Shelton Horsley Research Award:

Henry W. Gould, Department of Mathematics, West Virginia University, Morgantown, W. VA., for the paper entitled *Estimation of actuarial functions arising in coal mine valuation*.

Dr. Russell J. Rowlett, Jr., Editor of Chemical Abstracts Service (American Chemical Society), Columbus, Ohio, delivered the Sidney S. Negus Memorial Lecture: *The Future of Scientific Information*.

New Academy Officers were installed:

President: Dr. Ralph A. Lowry, University of Virginia

President-elect: Dr. Dale Ulrich, Bridgewater College

Secretary: Dr. S. Gaylen Bradley, MCV-VCU

Treasurer: Mrs. Vera Remsburg, John S. Battle High School, Washington County Schools

## COUNCIL MEETING

May 13, 1977

President Ralph Lowry called to order the meeting of the "new" Council at 7:55 a.m. on May 13, 1977 at the Ramada Inn, Petersburg. In attendance were Michael Bishara, Carvel Blair, K. P. Bovard, Gaylen Bradley, Blanton Bruner, Rae Carpenter, Kuldip Chopra, C. G. Cochran, Dennis Darby, Franklin Flint, Boyd Harshbarger, John L. Hess, George Jeffers, Gerald Johnson, Ronald Johnson, Ralph Lowry, Peter Mazzeo, Barlow Newbolt, Douglas Ogle, Paul Osborne, Allan Powell, Vera Remsburg, Ertle Thompson, Edward Turner, D. V. Ulrich, W. R. West, John White, and John Wise.

## CHAIRMEN OF STANDING & AD HOC COMMITTEES

### Committee

Awards

Constitution and Bylaws

Finance and Endowment

VJAS, Director

Long-Range Planning

Membership

Nominating

Publications

Research

Virginia Flora

Archives

Business Relations

Plan Science Advisory System

Science Museum System

Science Education

### Chairman

Lynn Abbott

Ed Turner

Rae Carpenter

John Hess

Frank Flint

W. R. West, Jr.

E. Wisman

John Wise

Bob Paterson

Peter Mazzeo

Boyd Harshbarger

Vacant

Ertle Thompson

Vacant

Virginia Ellett

and Art Burke

It was noted that the deadlines for nominations of Academy Fellows would be June 1, 1977.

President Lowry announced that the Executive

Committee, in its meeting held immediately prior to this Council meeting, had decided to recommend to the Council that Blanton Bruner be reappointed Executive Secretary. Dr. Powell moved and Dr. Jerry Johnson seconded the motion that the Council confirm Blanton Bruner's appointment as Executive Secretary-Treasurer. The Council approval of the motion was unanimous.

President-elect Dale Ulrich discussed the problem of attracting exhibitors to the annual meeting. The number of exhibitors is down this year from previous years. Rae Carpenter stressed the need to retain files listing the best contacts pertaining to exhibits, and that these files be passed on to the new Local Arrangements Committee. Dr. Gerald Johnson asked whether we should encourage educational exhibits as well as commercial exhibits. Dr. Bishara suggested distribution of questionnaires to the exhibitors soliciting their comments, advice and guidance. He also encouraged prominent listing of exhibitors in the program to encourage visits to the exhibits. Dr. Bradley suggested that educational exhibits and scientific posters be displayed in the exhibition area to attract members to the exhibits. Dr. Carpenter proposed that each "break" be listed in the program as "break to visit the exhibits." Perhaps a statement—BE SURE TO VISIT THE EXHIBITS—could be added to each page of the program.

Dr. Chopra reported that he had met with most of the section editors. There is some sentiment to publish the abstracts in advance of the annual meeting. Dr. Chopra indicated that the manuscript or a synopsis of the Horsley Award paper might be published in the Virginia Journal of Science. He proposed that abstracts published in the Virginia Journal of Science should be certified by the authors as their original contributions to the respective disciplines.

Dr. Peter Mazzeo reported that the publication of the Virginia Flora Atlas, a project of the Academy for many years, has run into some difficulties. Dr. Harville has the Atlas ready for publication, but the degree of the VAS participation in the publication is not clear. The Council requested Drs. Rae Carpenter and Lowry and representatives of the Executive Committee to meet with Dr. Harville to clarify the Academy's role and support for the Atlas' publication.

Dr. Osborne indicated that the Research Committee had \$1,300 left over this year. This amount will be carried over into the next fiscal year.

The geology section noted that the May meeting was a cause for concern and recommended that the Academy meet in April. It was noted that the Southeastern Biologists and American Physical Society also meet in April. President Lowry indicated that the meeting time was under review.

The Council noted with sorrow and regret the loss through death of a number of devoted members and loyal supporters of the Academy, and acknowledged their affection and esteem for their departed colleagues.

Dr. Powell, immediate past president, indicated his plan to write to Dr. Thomas Law, President of Virginia State College, the Local Arrangements Committee, and the exhibitors, expressing Council's appreciation for their support of the VAS program in 1977.

The meeting adjourned at 10:15 a.m.

# SIDNEY S. NEGUS MEMORIAL LECTURE

## THE FUTURE OF SCIENTIFIC INFORMATION\*

Russell J. Rowlett, Jr.\*\*, Editor, Chemical Abstracts Service

(\*Presented to the Virginia Academy of Science, Petersburg, Virginia, May 12, 1977; \*\* Dr. Rowlette is also a member of the Editorial Board of the Virginia Journal of Science)

It is a signal honor to present the Sid Negus Memorial Lecture. To be invited twice is recognition which I deeply appreciate your bestowing upon me.

Sid Negus was a close personal friend. His family and my wife's family were neighbors. It was Sid who first interested me in the art of presenting scientific facts to the general public. He was a master of public relations. Many times he and I collaborated on editorials on scientific subjects for the Richmond newspapers. I often wonder who has been composing such editorials during the last decade. After reading V. Dabney's excellent new book on Richmond<sup>1</sup> and finding so little reference to the city's achievements in science, I know you miss Sid and his public relations activities. I am certain V. Dabney would have consulted with him.

Nine years ago in Roanoke I described for you computer pathways to scientific information<sup>2</sup> concentrating on chemical and chemical engineering information as processed at Chemical Abstracts Service (CAS). Before we turn our attention to the future, I must bring you up to date with events during these nine years. In order to prevent just a recitation of statistics, I have included in my oral presentation a few colorful events in the travels of the CAS Editor over this period in search of a better understanding of the national interest in scientific information.

FIG. 1—Growth of CA in the 1970's

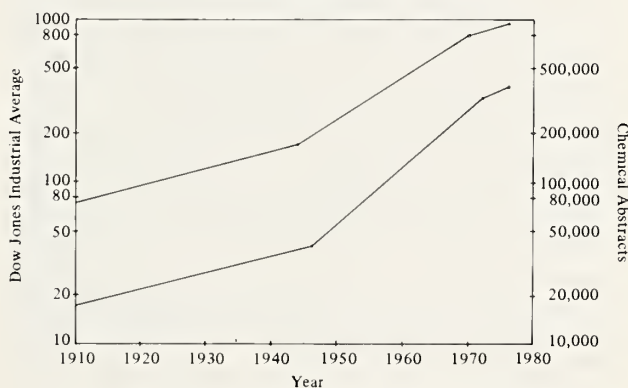
	1970	1976	
Abstracts published	276,674	390,905	
Average annual growth			6.2%
Documents cited	309,742	458,508	
Average annual growth			7.1%

In the last nine years CAS has referenced just over three million documents. In its first sixty years of existence, CA covered only just over four million documents. By the end of 1978, my eleventh year as Editor, I will have watched over production of more than half of the abstracts and well over half of the index entries ever published in CA. Figure 1 illustrates the continued growth of the chemical literature. The "documents cited" category includes the equivalent patents which CAS references in its Patent Concordance. (Only the first received patent on a single invention is actually abstracted. Later equivalent patents are cited in the Concordance.) The 7.1 percent growth is slightly lower than the 8.2 percent, almost steady state of former years. We do not have

yet a firm reason for this slight decline. Perhaps—and I must emphasize the "perhaps"—we are beginning to see some leveling off of the continued growth of the literature of chemistry. It has by no means stopped, but perhaps it is slowing down.

CAS operates the only chemical manufacturing plant which does not control its input raw material. Of course, we know the journals, reports, patents, conference proceedings, and other packages which we purchase, but we do not know how many documents of chemical interest these packages will contain. Also, we do not know when they will arrive. Document receipts are effected by airline and dock-worker strikes, fires in post offices, and some suppliers, such as the Soviets, who wait until they have a certain size box filled—size of box unknown. We have invested many hours and consultant dollars trying to devise adequate methods for input forecasting. We have tried just about everything. One of my experienced Managing Editors is convinced the following comparison has value, Figure 2. This is a logarithmic plot.

FIG. 2—Growth of Chemical Literature



This is an interesting concept. I present it here not as a solution but as an indication of one of many factors which may be acting to influence the output of the research scientist. Certainly there is a connection between worldwide industrial research spending and the number of papers which that spending finally produces. Maybe we can follow the stock market and predict the number of CA abstracts. Right now, it is as good a forecasting technique as we have, and better than many we have tried.

You are an audience composed primarily of authors of scientific documents. The late Dick Kenyon often said the primary purpose of the original document is to enhance the prestige of the author. I don't

<sup>1</sup> Virginius Dabney, *Richmond, The Story of a City* (Garden City, New York: Doubleday and Company, Inc., 1976).

<sup>2</sup> Russell J. Rowlett, Jr., *Virginia Journal of Science*, 19, (1968), p. 137.



know if this is true, but I can attest to great author interest in the abstract of his paper. Authors let the CAS Editor know if there is the slightest mistake in coverage of his document. Also, from all over the world come impassioned pleas for CA abstracts of unpublished manuscripts, personal letters, and even notes on the back of envelopes. Of course, an author has to get his disclosure published before it can be abstracted, but the existence of these letters attests to the importance which authors attach to abstracts. CAS, being staffed by humans, does sometimes err. We've been known to say the reaction was heated when it actually was cooled. We've lost ethyl groups from molecules and on occasion we've even invented nonexistent molecules. In every case, it is the author who points out the error. Being an editor, I know some readers love to find errors and, with today's subscription prices, I do not wish to disappoint them. I wish to emphasize that authors have great and genuine interest in their papers and abstracts of those papers.

Figure 3 indicates how this author interest produces for one abstracting service for one year.

FIG. 3—Source Documents (1976).

Screened	2,900,000
Selected	458,508
Abstracted as new	390,905
Cross-referenced as equivalent patents	67,603

83% Periodicals and other reports  
(140 countries, 50 languages)  
17% Patents from 26 countries

Almost three million documents were screened from which CAS selected 458,508 for coverage; 390,905 were abstracted and 67,603 patents referenced in the Concordance. The documents arrived from 140 countries and appeared in 50 languages. We run an intellectual manufacturing operation. We prepare, edit, and process more than 1,700 abstracts and over 15,000 index entries of all types each and every day.

We've looked at only the abstract part of this information business. Today CAS has more than seven million abstracts in its data base. Without thorough, in-depth indexes, nothing could be found in that haystack. Figure 4 illustrates the huge content of the Ninth Collective Index which we are publishing this year and next.

FIG. 4—Ninth collective index period (1972-1976)

Documents Abstracted	1,772,194
Equivalent Patents	251,819
Total Documents Cited	2,024,013
Author Index Entries	4,668,027
General Subject Index Entries	3,746,436
Chemical Substance Index Entries	7,306,750
Total Pages	100,750
Total Books	62

Over 100,000 pages in 62 books will be composed through the computer system, printed by two print-

ers, and delivered to subscribers in less than 24 months. This is the largest index publication venture in all history, and yet it will be delivered in the shortest time frame of any CA Collective Index. The index contains almost 16 million entries of all types for more than two million documents.

A decade ago the American Chemical Society's Chemical Abstracts Service set out to build a highly automated information processing system.<sup>3</sup> Its goal was to produce printed abstracts and indexes more efficiently and economically while at the same time creating a machine-readable data base that could provide new routes of access to chemical and chemical engineering information.

Although much remains to be done, a significant part of this goal has been realized. It is only through such a system that we can handle the volumes of information illustrated in Figures 3 and 4.

Our present position has been achieved only with significant costs. About 45 million dollars have been required to date in the development of the computer-processing systems; 25 million was obtained through grants and contracts from the National Science Foundation and other government agencies over a period of 11 years, and 20 million was obtained from the subscription revenues of CAS. Today the subscription price of CA is \$3,500. However, despite the increased subscription price, the per unit cost to the subscriber for one abstract plus all of its accompanying index entries has decreased in the last 10 years by over 28 percent, calculated on a constant dollar basis. This has occurred even though the number of index access points per abstract has increased very significantly.

I have illustrated the large volume and high costs of scientific information in the 1970's. A comprehensive study issued in 1973 by the Organization for Economic Cooperation and Development (OECD)<sup>4</sup> predicted that there will be at least four to seven times as much information generated in 1985 as was generated in 1970. Personally, I believe this is an overestimation, at least for chemistry. However, the report serves to emphasize the magnitude of the task to be faced in the future.

The cost of abstracting and indexing services, such as CA, has escalated to an amount which only institutions can afford. There are no longer any individual subscribers to CA. Also, in recent years many small industries and a few small colleges have been forced to drop their subscriptions because of budget restrictions. This cost problem is not limited to abstracting and indexing services. The original, primary journals are experiencing the same proportional financial pressures, and their prices have climbed in parallel escalations. For example, the *Journal of the American Chemical Society* sold to ACS members for \$4 in 1949. Today, the journal costs members \$28 and nonmembers \$112. By 1980 the prices are forecast as \$41 and \$164 respectively. Soon the primary journals, like CA, will be only library items with few individual

<sup>3</sup> CAS Staff, "Toward a Modern Secondary Information System for Chemistry and Chemical Engineering," *Chemical and Engineering News*, June 16, 1975, p. 30.

<sup>4</sup> G. Anderla, *Information in 1985: A Forecasting Study of Information Needs and Resources*, OECD Publication No. 31, 843 (1973).



subscriptions, or individuals will be able to subscribe to only a very few journals.

I could assume the popular position and state these two related problems of huge volumes of content and ever increasing costs will be solved by "the machine." Many are adopting just such a stand. John Senders of the University of Toronto<sup>5</sup> predicts "an electronic journal" which will save time, money, and storage space. Mary Jones, University of Illinois Law School,<sup>6</sup> describes computerized information systems as "the books, magazines, and journals of the future." We could list many well thought out and documented proposals. I do not disagree. The computer will play a prominent role in the information storage and transfer processes of the future. However, in my opinion, it will not replace the printed word during the life times of most of us in this audience. Eliel<sup>7</sup> has pointed out three purposes for the written scientific paper: "to inform or alert those who are working in the same field, to educate those who are working in related fields and want to expand their horizons, and to serve an archival function for posterity who, in later years, may wish to retrieve details of information accumulated and stored earlier." The computer performs the latter archival function best. We do not yet know how to browse within a computer data base. We do not yet know how to build into computer-search systems the fascinating act of serendipity. In a computer, you find only the exact item for which you search. You uncover none of those flashes of ideas or odd tidbits of information which you just happen to see while looking for something else.

The printed word has great continuing value. I am not yet ready to moan its demise. So, what do we do about the future of the ever growing pile of scientific information and its ever increasing cost?

I offer you a straightforward and yet complex answer. We can solve the problem only by attacking it at its source. You, the authors of scientific papers, are the source. You have it within your hands to begin to help solve the problem. Those of us in the publishing business must join hands with you, the authors, to develop forms of shortened original disclosures of your results of research and technology. Examples may be the synopsis journals which the West Germans and British<sup>8</sup> are investigating, and the dual-journal experiment<sup>9</sup> of the American Chemical Society. No matter whether one nation or one publisher adopts a synopsis or summary journal, you can start now to help build a better future for scientific publishing.

Today's scientific papers are too long. They include too many extraneous details. I suggest they include data not needed for the particular points being made in the paper. The current pressure for indexing services to include access points for every item of numer-

ical data is very great. We have estimated that chemists are capable of actually making more than 1,100 different measurements of properties, uses, and applications of chemical substances. This has stemmed from the proliferation of sophisticated analytical equipment present in most modern laboratories. The human investigator cannot help but try out his newly synthesized substance in every machine available. Then, of course, he must report his results whether pertinent or not—and discuss them. Multiply this by the almost half million papers which we abstract and index, and you begin to feel the problem.

There is another little practice which haunts us; the habit of some authors to make three marginal papers out of one good paper. The duplication of indexing here is tremendous! This practice is not limited to journal articles. We recently found four patents which issued in one country as divisions of one original application. Each contained information on 511 substances; and, because of the needs of the future users, all 511 had to be indexed for all 4 divisional patents. I recognize the need for publication in both the academic and industrial communities, but somewhere we have got to ask ourselves, "Is this publication really necessary?" There are parallels with our recently grasped requirement for energy conservation and our several-year interest in the ecology of our planet. Would that we could apply some of this thinking to our scientific information future. The "publish or perish" syndrome and the weighing of the number and length of published works as an indication of tenure accomplishments have both got to be made invalid.

When I mentioned the synopsis journal earlier, there were visible shivers in the audience. This, unfortunately, is an emotional issue. Terrant has reported<sup>10</sup> in the ACS dual-journal experiment there was no mandate for conversion of a regular journal to a synopsis journal, but there was "strong evidence of an interest in, and need for, summary journals." In my opinion, this result will add to our future problem, not help solve it. It suggests there will not be a replacement of a journal with a shorter one, only a continuation of the present complete journal and the addition of yet another journal in the form of summaries.

In addressing the 1975 Institute of Electrical and Electronics Engineers' Conference on Scientific Journals,<sup>11</sup> I advocated strongly some form of summary paper with the bulk of the supporting data deposited in an accompanying archival form. I continue to favor this procedure as one means of attacking our future. During this 1975 meeting, I admonished the publishers to accept responsibility for the archival part of the total paper. Today, too many deposited documents are in forms which are not permanent, are not prepared and properly deposited, and will not be found or used by future generations. Publishers have an important role to play in helping preserve the future of scientific information. Many have not rec-

<sup>5</sup> John Senders, "The Scientific Journal of the Future," *American Sociologist*, 11, (1976) pp. 160-4.

<sup>6</sup> Mary G. Jones, "Computerized Information Systems as the Books, Magazines, and Journals of the Future," *Bulletin of the American Society of Information Science* 1, (1975) pp. 19-21.

<sup>7</sup> Ernest L. Eliel, *Journal of Physical Chemistry* 78, (1974) pp. 1339-43.

<sup>8</sup> L. C. Cross, "The Primary Scientific Literature in the Next Few Years," *ASLIB Proceedings* 26, No. 11, (1974) pp. 425-9.

<sup>9</sup> S. W. Terrant, Jr., and L. R. Garson, Summary Report, Evaluation of a Dual Journal Experiment, NSF Div. Science Information Report, March, 1977.

<sup>10</sup> S. W. Terrant, Jr., and L. R. Garson, Summary Report, Evaluation of a Dual Journal Experiment, NSF Div. Science Information Report, March 1977.

<sup>11</sup> Russell J. Rowlett, Jr., "A Total Publication System for Scientific Information," *IEEE Trans. on Professional Communication*, PC-18, No. 3 (1975) pp. 229-33.



ognized this responsibility. You, as authors, have at least an equal responsibility. I ask, please, that you try first to understand the problems and then to think about what you as an individual can do with those papers which you write and those papers which your students write. I am afraid that like so many modern problems the solution to our scientific information future "begins at home."

In this business, we not only have too many papers, we also have too many new journals of questionable value. Sir Harold Thompson, past president of the International Union of Pure and Applied Chemistry<sup>12</sup> has declared, "The fragmentation of science through the mushroom growth of new journals and the trend toward over-specialization is bad for science and the general training of young scientists. The discovery of new physiochemical techniques and their application to chemical problems does not demand the creation of new journals for each of them. Yet, this is being allowed to happen at a time when we are supposed to be emphasizing the integration of science and stressing the importance of interrelationships. Much of the rush for quick publication by some research workers today is unjustifiable."

Sir Harold points to the impossibility of setting up any international agency to control the creation of new commercial journals. He says the power is in the hands of scientists themselves. Scientists need not acquiesce to the pressures from publishers and agree to serve on editorial boards for new journals; and they should restrain themselves and their young colleagues from sending papers to such journals.

I am sure I am classed by some contemporaries as ultraconservative, but I continue to be a strong advocate for our peer review system and our practice of refereeing papers in all first-class journals. Perhaps we need to devise a technique for refereeing new journals before they begin publication.

Now, with too many papers too long, and contained in too many journals, we still have a severe problem in actually locating copies of the journals. "The best information system in the world becomes meaningless if the ultimate user does not have access to the original document." This statement<sup>13</sup> was part of the original objectives of the National Federation of Abstracting and Indexing Services (NFAIS). Yet, after almost 20 years of NFAIS existence, and even more years of discussion by the several large accessing services, almost 16 percent of the original journals

continue to be unavailable within the United States.<sup>14</sup> Who is responsible for providing these important documents? The original publishers? Libraries? The accessing services? The federal government? All probably have a role to play, but none has stepped forward really willing to take on the major burden. The solution to this problem is obviously complicated by the continuing copyright questions. But someone has to accept the responsibility if the individual user is to be served. Should the United States resort to a national library system similar to those in Canada, the United Kingdom, and other countries? There certainly is no interest in such a system within the present federal hierarchy. Private interests until very recently appeared to oppose one national repository. However, in recent weeks one publishing association has come forward with a partial plan for a central clearing house for collection of royalties and supply of copies. A prominent industrial information expert has been loaned for a few months to study this concept and to make recommendations. We sincerely hope that some concrete procedure will evolve from this concept. I believe that a workable document access program is attainable if we really put our minds to it. Today, however, the problem is still with us for the future.

I have tried to stimulate your thoughts along lines about which you as individuals can do something constructive. Most of us cannot truly understand computers, write computer programs, or design computer systems, so I have avoided this end of our business. Let me please close with a thought which may, as the saying goes, just blow your mind. Most of the publishing to this point in history has been done by Western nations, following Western experimental science. (For our purposes we are considering the Soviet Union as a Western nation.) Thus, only 25 percent of the world's actual population has contributed to what I explained nine years ago was not really a scientific explosion. Today, we see two billion people, half the world's population, just beginning to develop significant independent civilizations and scientific philosophies. They now appear to be adopting Western technology and Western science. If and when this half of the world's population begins research and publishing on the Western scale, we will indeed see a scientific publication explosion. Imagine what Chemical Abstracts will be like with three fourths of the world's population following Western scientific philosophy and six billion people in the world!

<sup>12</sup> Sir Harold W. Thompson, "Proliferation of Journals," *Chemical and Engineering News* 52, (October 7, 1974) p. 2.

<sup>13</sup> National Federation of Abstracting and Indexing Services History and Issues, 1958-1973, National Federation Abstracting and Indexing Services, Philadelphia (March, 1973).

<sup>14</sup> J. L. Wood, "A Review of the Availability of Primary Scientific and Technical Documents within the United States," U. S. Office of Education, Washington, Final Report Project 7-0930 (1969).

# ABOUT OUR NEW ACADEMY OFFICERS

## PRESIDENT

Dr. Ralph A. Lowry, professor of engineering science and applied science at the University of Virginia and President-elect of the Virginia Academy of Science was installed as the VAS President for the year 1977-78 at the Academy Assembly held on May 12, 1977 at Ramada Inn, Petersburg, Virginia.

Dr. Lowry received his B.S. (electrical engineering) in 1949 and Ph.D. (physics) in 1955 from Iowa State College. He has held research positions in the Research Laboratories for Engineering Science at U. VA.'s School of Engineering and Applied Science during 1955-62, and has been on U. VA.'s instructional staff since 1960. He chaired the department of engineering science and applied science during 1965-72.

Dr. Lowry has been a very keen and active member of the Academy, particularly in his capacities as a member of the Long-Range Planning Committee (1969-72), Chairman of the Space Science and Technology section (1970-71), Councilman (1971-74), Secretary of the Academy (1974-76) and the President-elect (1976-77).

## PRESIDENT-ELECT

Dr. Dale V. Ulrich, Dean of the College and professor of physics at Bridgewater College was elected President-elect at the Academy Conference held on May 12, 1977 at the Academy Assembly held the same day at Ramada Inn.

Dr. Ulrich received his B.S. (1954) from Laverne College, M.S. (1956) from University of Oregon and Ph.D. (1964) from the University of Virginia. He has taught at Bridgewater College and Madison College during 1958-67, and has been the Dean of the College since 1967.

Dr. Ulrich has made significant contributions to the Academy in his roles as member of the Long-Range Planning Committee (1969-71), Chairman of the Long-Range Planning Committee (1971-74), Director of the Visiting Scientists' Program (1974-76),

Treasurer of the Academy (1975-76), and member of the Finance and Endowment Committee since 1975.

## SECRETARY

Dr. S. Gaylen Bradley, chairman and professor of microbiology at Medical College of Virginia and Secretary of the Virginia Academy of Science was reelected to a second term as the secretary at the Academy Conference, and installed as such at the Academy Assembly.

Dr. Bradley received his B.A. and B.S. (1950) in microbiology from Southwest Missouri State College, and M.S. (1952) and Ph.D. (1954) from Northwestern University. He did his postdoctoral research at the University of Wisconsin (1954-56), and he has held teaching positions at the University of Minnesota (1956-68) and at MCV-VCU (1968-).

Dr. Bradley has ably served the Academy, principally in his roles as a Councilman (1968-75) and Secretary (1976-77).

## TREASURER

Vera B. Remsburg, Chairman of the science department at Herndon High School and Fellow of the Virginia Academy of Science was elected Treasurer of the Academy at the Academy Conference and installed in that capacity at the Academy Assembly.

Mrs. Remsburg received her B.S. (1942) and M.S. (1952) in biology from Longwood College and University of Virginia, respectively. She has pursued additional studies at the College of William & Mary, U. VA., Roanoke College, VPI & SU, and Madison College. She has taught biology at Herndon High School since 1942.

Mrs. Remsburg has been one of the most dedicated members of the Academy in a variety of capacities: member, VJAS Committee (17 years), Secretary and Vice-Chairman (Biology Section), Va. Flora Committee (3 years), Chairman and Secretary (Science Teachers' Section), member of the Resolutions Committee, Chairman of the Awards Committee, and member of the Long-Range Planning Committee. The VAS Council elected her an Academy Fellow in 1975.



# 1977 J. SHELTON HORSLEY RESEARCH AWARD

HENRY WADSWORTH GOULD



Henry Wadsworth Gould (right), the recipient of the J. Shelton Horsley Research Award (1977) with Kuldip P. Chopra, also winner of the 1974 award. Professor Gould edits proceedings of the W. Virginia Academy of Science.

Henry Wadsworth Gould, professor of mathematics at West Virginia University, and Editor of the West Virginia Academy of Science Proceedings received the J. Shelton Horsley Research Award for 1977. Professor Gould won the most coveted VAS award which carries a certificate and a \$500 cash prize for his paper on *Estimation of Actuarial Functions Arising in Coal Mine Valuation* presented to the Astronomy, Mathematics, and Physics section at the 55th Annual Meeting of the Virginia Academy of Science held at Virginia State College, Petersburg.

The recipient of the award was born in Portsmouth, VA on August 26, 1928. He attended Old Dominion College, and received his B.A. (1954) and M.A. (1956) in mathematics from the University of Virginia. He has pursued further graduate studies at U. VA. and University of North Carolina. He has held teaching positions at West Virginia University.

Professor Gould has prepared two books: *Combinational Identities* (Revised Ed.) and a 740 page *Valuation Handbook* (in press). He is an author of over 120 papers in various aspects of mathematics, including combinatorics, number theory, special functions, and history of mathematics and astronomy.

He was elected Fellow of the American Association for the Advancement of Science (AAAS) in 1963 and holds memberships in several local, state, national, and international professional societies: American Mathematical Society, Mathematical Association of America, Society for Industrial and Applied Mathematics, Institute of Mathematical Statistics, Deutsche Mathematiker-Verinigung, Polskie Towarzystwo Matematyczne, National Academy of

Sciences of India, Virginia Academy of Science, West Virginia Academy of Science, Pi Mu Epsilon, Sigma Xi, American Association for the Advancement of Science, The Fibonacci Association, American Statistical Association, Association for Computing Machinery, Association for Women in Mathematics, National Council of Teachers in Mathematics and West Virginia Council of Teachers of Mathematics.

Professor Gould has varied interests. He holds amateur and commercial radio operator licenses and is interested in poetry, genealogy, cryptography, Sherlock Holmes (publication in Baker Street Journal), hiking, and Chinese language.

## MEDICAL SCIENCE SECTION AWARDS

At the 55th Annual Meeting of the Virginia Academy of Science, Medical Sciences Section, the following graduate students won distinctions for their scientific presentations.

First prize was awarded to S. Offenbacher (co-author E. S. Kline) for "Structural Implications of Non-Histone Nuclear Protein Phosphorylation," Department of Biochemistry, Medical College of Virginia, Richmond. L. W. Jenkins (co-author J. T. Povlishock, D. P. Becker, J. D. Miller, and H. G. Sullivan) won second prize for "A Morphological Study of Neuronal Alterations in Cat Cerebral Cortex Following Global Ischemia," Departments of Anatomy and Neurological Surgery, Medical College of Virginia, Richmond.

Honorable mentions went to the following (all at MCV): D. E. Berry (co-author J. M. Collins) for "Laser-Activated Determination of Human Cell DNA Content," Department of Biochemistry; R. J. Caldwell (co-authors J. I. Townsend and M. J. V. Smith) for "High Level of Inbreeding in a Native Virginia Population," Department of Human Genetics and Division of Urology; D. L. Cochran (co-author K. R. Shelton) for "Interaction of the Major Nuclear Envelope Polypeptides Revealed by Disulfide Bond Formation," Department of Biochemistry; G. Maughan (co-authors J. H. Johnson and J. A. Rosecrans) for "Decreased Whole Blood Luteinizing Hormone in Ovariectomized Rats After Microinjection of Morphine and Methadone into Midbrain Raphes," Department of Anatomy and Pharmacology.

Special scrolls were presented for all awards. First prize winner also received \$50 and second prize \$25. Funds were kindly provided by A. H. Robins Co.

# Abstracts of Papers

## Section of Agricultural Sciences

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

INSECT PROBLEMS ON FIELD CORN IN HAITI. W. A. Allen, Dept. of Entomology, VPI&SU, Blacksburg, Va. 24061

Surveys of insects on field corn in the Caye Plain of Haiti during November 1976 and March 1977 revealed that a number of insects attack seedling corn plants. The percent of plants under 30" tall that were infested with Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) ranged between 16 and 65% with a mean infestation rate of 34.8%. The 16% infestation level was in the only field that was treated with insecticide (carbaryl). A partially completed list of the insects feeding on seedling corn include: *Spodoptera frugiperda* (J.E. Smith); *Spodoptera eridania* (Cramer); *Spodoptera dolichos* (Fabricius); *Heliothis zea* (Boddie) and; *Peregrinus maidis* (Ashmead). Grain in storage also is attacked by insects and seed corn treated with chlordane and captan ranged between 8 and 25.3% infestation 4 months after harvest. The principal insects infesting grain corn were: *Sitophilus zeamais* Motschulsky, *Tribolium castaneum* (Herbst) and a moth presumed to be *Sitotroga cerealella* (Olivier) (confirmation pending). Beneficial insects collected on seedling corn included the coccinellids *Cycloneda sanguinea* (Linnaeus), *coleomegilla maculata* (DeGeer) and *Hyperaspis* sp.

Appreciation is extended to the Insect Identification and Beneficial Insect Introduction Institute, USDA, for insect identification.

RECENT DEVELOPMENTS IN THE STUDY OF THE GELECHIID MOTH, *FRUMENTA NUNDINELLA*. T. E. Bailey\* and L. T. Kok. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Biological studies of the Gelechiid moth, *Frumenta nundinella*, initiated in 1975, were continued during the summer and fall of 1976. Two broods were found attacking horsetnettle (*Solanum carolinense* L.). First brood larvae were observed in mid-June feeding at the terminal growth points of some plants. Each was enclosed in a tight hollow chamber formed by the leaves of the plant. It appeared that the formation of the chamber was influenced by the presence of a living larva. The larvae completed development in mid-July and emerged as adults in late July and early August. Larvae of the second brood infested the berries of horsetnettle as they did the previous year, and emerged as adults from the berries throughout September. Substantial damage to the plants resulted from both modes of feeding. Further study is in progress to determine the overwintering stage, host specificity and impact on the plant.

FERMENTATION CHARACTERISTICS OF SWINE MANURE ORCHARD GRASS SILAGE. J. C. A. Berger, J. P. Fontenot and E. T. Kornegay. Dept. of Animal Science, VPI & SU Blacksburg, Va. 24061.

Swine manure was ensiled with different proportions of chopped orchardgrass hay in small laboratory type silos. Fresh swine waste to hay ratios were: 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, fresh basis. Good ensiling occurred with 70:30 to 40:60 mixtures, with pH values of less than 5. Lactic acid values were above 2.0%, dry basis, for 40:60 to 70:30, and over 3.0% for 50:50 and 60:40 ratios. There were large reductions in total bacteria and total coliforms, and complete destruction of fecal coliforms following ensiling. Swine waste and hay were ensiled at 40:60 and 60:40 ratios in sealed double thickness plastic bags inside 208 l steel drums for digestion and palatability trials. Diets for two digestion trials using 12 growing wether lambs were: 1) hay, 2) swine manure-hay (40:60) silage, 3) swine manure-hay (60:40) silage, and 4) hay-SBM. Organic matter digestibility was 56% for the ensiled materials, compared to 54% for the hay. Apparent digestibility of crude protein was higher ( $P < .05$ ) for the 60:40 silage than for the 40:60 silage. Crude fiber digestibility tended to be higher for the lambs fed the ensiled material, compared to those fed hay. A 10-day acceptability trial with 24 growing wether lambs, found no significant differences in dry matter intake between lambs fed the ensiled materials and those fed hay alone or supplemented with SBM.

INBREEDING VS. SELECTION IN BEEF CATTLE AT THE FRONT ROYAL STATION. I. GROWTH TO WEANING. K. P. Bovard and W. T. Butts† Dept. of Animal Science, V.P.I. & S.U., Blacksburg, Va. 24061 and U.S.D.A., Knoxville, TN. 37916.

Growth and type data to weaning on 3663 calves born from 1950 through 1969 were subjected to a series of least squares analyses. Dependent variables included birth weight; average daily gain (ADG, lbs./day); fall weight, lb.; and, fall type score (Good=10; Choice=13; etc). Independent variables were age of dam, sex of calf, fall age in days, mating system, line with mating system and time expressed in model 1 as years, linear; model 2 as years, linear and quadratic; and model 3 as generations. Estimates of main effects from all 3 models were in good agreement. When inbreeding of calf was treated as a dependent variable,  $R^2$  values using model 3 were .83, .84, and .87 for Angus, Hereford and Shorthorn data, respectively. Corresponding results using inbreeding of dam were .72, .41, and .76, respectively. Examples will be presented and discussed.



INBREEDING VS. SELECTION IN BEEF CATTLE AT THE FRONT ROYAL STATION. II. POSTWEANING GROWTH AND TYPE. K. P. Bovard and W. T. Butts\*, Dept. of Animal Science, V.P.I. & S.U., Blacksburg, Va. 24061 and U.S.D.A., Knoxville, TN. 37916.

Simple means were obtained for each sex-breed-mating system in preliminary analyses of postweaning growth results. Data were from 2611 calves born from 1950 through 1969. They were 606 bulls, 1642 heifers, and 363 steers; 942 Angus, 739 Hereford, and 930 Shorthorn; and 1311 were from inbred lines, 1300 from selection lines. Management and feeding of the three sexes was quite different, requiring separate analyses for each sex. For example number of calves, average inbreeding of dam and of calf, average daily gain (ADG) to weaning, ADG on postweaning test, and yearling type score for inbred Shorthorn bulls were 129, .17, .28, 1.75, 2.55 and 11.3, respectively. For Shorthorn bulls from the selection lines, corresponding values were 99, .04, .05, 1.91, 2.77, and 12.3, respectively. Differences were comparable in the other sex-breed-mating system classes. Examples will be presented and discussed.

EFFECTS OF CALVING DIFFICULTIES ON SUBSEQUENT BREEDING AND CALVING PERFORMANCE. S. Bulgreen\* and K. P. Bovard, Dept. of Anim. Sci., VPI&SU, Blacksburg, Va. 24061

Records studied were from the Beef Cattle Research Station, Front Royal, Va., conducted jointly by VPI and USDA 1950-73. A total of 5147 matings from 1958 through 1969 was classified by line and breed of sire, dam and calf, with most matings planned in one of 12 highly inbred (closed) lines or in one of 7 non-inbred (open) single-trait selection lines. Births were classified binomially on three traits: survival, assistance to dam at calving, and presentation. Also, cows' matings were ordered serially, and called times (years) exposed. For the 5147 matings included, breeding results were coded with a one for subsequent calves born, and a 2 for infertile matings. Chi-square for mating result by times exposed was 53.92\*\*, a clear suggestion of the positive association of fecundity and longevity, the latter partly under man's control. For 3989 births, chi-square for type of birth x times exposed was 167.91\*\*. Both simple and multiple regressions were calculated for type of birth as affected by dam's age in years, by number of times exposed, by breed and line of dam, by sex of calf, and by the cow's lactation status when bred. Resulting  $R^2$  values were from 0.014 to 0.045, all statistically highly significant. The linear regression of type of birth on times exposed was  $-.061^{**} + .008$  per year. Other details will be presented and discussed.

AGRICULTURE AT VIRGINIA STATE COLLEGE. M. T. Carter. Dept. of Agriculture, Virginia State College, Petersburg, Va. 23803.

Agriculture has always been an integral part of the total educational thrust of Virginia State College. In the early days (1882-1902) of the institution, it was a part of the general education requirement of all students. Later (1902-1922) agriculture was only required for those taking the two year Normal School preparation for elementary teaching. In its subsequent developments (1922- to date) programs have been administered through a School of Agriculture, offering majors in Animal Science, Agronomy, Agricultural Education, Agricultural Economics, Horticulture and the M.S. degree in Agricultural Education. With these programs have been research, associations with commodity groups, professional organizations, the USDA, other colleges and the Cooperative Extension Service. Results to date show significant contributions in the education of those of limited opportunities, both resident students and off-campus clientele. Practically all of the graduates have found professional employment; more than one-fourth of the graduates have earned terminal degrees from the leading Universities of this country. The programs provide an educational facility in agriculture for this area of the state, job opportunities and a major support to the mission of the college in higher education.

EFFECTS OF METHYL-2-BENZIMIDAZOLECARBAMATE AND ITS SALTS ON THE GROWTH OF PLANTS. G. L. Clement and R. J. Stipes. Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

The effects of MBC (methyl-2-benzimidazolecarbamate), its salts (MBC·HCl, MBC·H<sub>3</sub>PO<sub>4</sub>), and benomyl on the growth and development of eight selected plant species was observed. In two experiments, soil-drenched and soil-incorporated applications of the fungitoxicants to cotton, mimosa, peanut, pin oak, soybean, tobacco, zinnia, and tomato showed both stimulatory and inhibitory effects. In Study I, soil-drench applications of MBC and its salts at concns of 10, 50, 100, and 300 µg/ml gave increases in mean height, fresh and dry weight at the lower levels. Growth suppression was noted at the higher application rates, but no phytotoxic symptoms were observed. Soil-incorporated benomyl was the only chemical used in Study II. Concns 10, 50, 100, 300, 500, 1,000 and 2,000 µg/mg of soil showed growth stimulation at the lower concns and much suppression of growth at the higher levels in most species treated. Phytotoxicity was observed on soybean, tobacco and tomato at the highest concn.

SPECTROPHOTOMETRIC DETERMINATION OF UNTREATED, WATER DILUTED, BLOOD PLASMA DETECTING NUTRITIONAL PROTEIN LEVELS IN CATTLE. G. Colmano and T. E. Lesch, Dept. of Veterinary Science, VPI & SU, Blacksburg, VA 24061

A spectrophotometric determination (Colmano, G., AAVLD Proceedings Book 1976) on steers' blood serum and dairy cows' blood plasma (EDTA treated) were diluted with HOH and recorded at 205, 278 and 414 nm, respectively for the determination of synthesized (anabolic), circulating (metabolic), and breakdown (catabolic) levels of protein. The anabolic-metabolic-catabolic levels of protein in blood plasma correlated to levels of protein supplementation. The spectrophotometric determination clearly indicated that steers receiving Choline plus Soy Bean Meal had the highest levels of anabolic, metabolic and catabolic proteins. Urea, Soy Bean Meal and Choline plus Urea supplemented steers followed in decreasing order of protein levels. In dairy cows freshened less than 80 days, while a 17% protein supplement gave the highest anabolic, lowest metabolic and second highest catabolic protein levels, a 13.5% protein supplement gave the lowest anabolic, lowest metabolic and second highest catabolic protein levels. In dairy cows freshened more than 80 days, while a 17% protein supplement gave the second highest anabolic, highest metabolic and highest catabolic protein levels, a 13.5% protein supplement gave a median level of anabolic, metabolic and catabolic proteins.

INBREEDING TO IMPROVE YIELD AND COMBINING ABILITY IN MAIZE. C. F. Genter, Dept. of Agronomy, VPI & SU, Blacksburg, Va. 24061.

A series of experiments has been conducted with maize over the past 20 years to try to produce an inbred population which is more productive than its parent. One diverse population was inbred by four cycles of recurrent selection for S<sub>1</sub> inbred yield. Coefficient of inbreeding increased about 20%, yield increased 22%, and combining ability increased 11%.

A second population originated from random crosses among F<sub>2</sub> plants of a single cross hybrid. Four cycles of recurrent selection based on intrapopulation-cross yield have been completed. Coefficient of inbreeding increased from 50% for the original crosses (cycle 0) to about 60% for C<sub>4</sub>. Mean yield increased from 55 to 80% of the F<sub>1</sub> check. All C<sub>4</sub> yields were higher than the mean of C<sub>0</sub>; the highest C<sub>4</sub> yield was equal to that of the F<sub>1</sub>.

Eighteen selfed lines derived from C<sub>3</sub> and C<sub>4</sub> were crossed to a common tester; the crosses were grown in a replicated test in 1976. The mean yield of C<sub>4</sub> crosses was significantly higher than that of C<sub>3</sub> crosses and yields of three C<sub>4</sub> crosses ranged from 3.2 to 10.6% higher than that of the commercial hybrid check. The latter increase was significant at the 5% level.

Improvements in both population yield and combining ability are consistent with genetic theory.

FIELD LEACHING STUDIES OF THREE LANDPLASTER PRODUCTS VARIANT IN PARTICLE SIZES. D. L. Hallock, Tidewater Research and Continuing Education Center, Va. Polytechnic Inst. and State Univ., Holland Station, Suffolk, Va. 23437.

This experiment was conducted on Woodstown lfs from June 8 to September 20, 1976 to study the relative effectiveness of various particle sizes of landplaster (LP) as sources of Ca in the peanut fruit zone (0- to 4-inch depth). Plots 3 ft. in diameter were surrounded by sheet metal bands pressed into the soil to preclude runoff and ensure penetration of measured rainfall. Three LP (anhydrite) products were broadcast at 0, 600 or 1200 lb/a. Soil samples from the 0 to 4, 4 to 8, and 6 to 12-inch depths were taken six times during a 102-day period. Rainfall was below normal by 7.6 in. during the first 72 days, but 6.8 in. occurred during last 30 days for a total of 14.1 in. (-4.5 in.) during 102-day period. Increased contents of water soluble soil Ca in the fruit zone were highest about 16 days after LP application, then declined steadily. It accounted for about 40% of the Ca applied as historic fine LP and 35% of that as -6 +50 mesh LP, whereas -4 +20 mesh LP had only a small effect, especially at the lower rate. Differential effects of LP particle size on exchangeable soil Ca levels were much less. In all three layers following initial soil Ca increases for 40 to 50 days after LP application, soil Ca levels declined markedly toward end of sampling period. LP particle size effects were less at the higher rate. Dry weather may have suppressed the relative effectiveness of the -4 +20 mesh LP.

EFFECTIVENESS OF GENERAL-USE INSECTICIDES IN SMALL MIXED-VEGETABLE PLOTS. R. D. Irwin and M. A. Latheef. USDA-CSRS Research Program, Virginia State College, Petersburg, Va. 23803

The efficacy of four general-use insecticides, including carbaryl, malathion, rotenone-pyrethrum mixture, and Thuricide, in replicated mixed-species vegetable plots was determined during 1976 at Petersburg, using yield-based parameters. The imported cabbage worm, cabbage looper, Mexican bean beetle, onion thrips, and squash vine borer were observed feeding on their respective hosts throughout the season. At harvest, the most effective control of onion thrips was achieved with malathion and carbaryl. Carbaryl effectively controlled Mexican bean beetle and stimulated total yield of bush bean. Chemical applications did not have a significant effect on the yield of other cultigens included in this study. (Supported by CSRS Grant #416-15-69)

EFFECT OF SOW PROTEIN FEEDING PROGRAMS ON ANTIBODY RESPONSE IN PIGS. S. N. Haye, E. T. Kornegay and D. C. Mahan. Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061 and Ohio Agricultural Research and Development Center, OSU, Wooster, Oh. 44691.

Antibody response and performance of piglets from sows fed varying crude protein (CP) levels during gestation (G) and lactation (L) were measured over two consecutive parities (P). Sows received one of the following dietary treatments throughout the reproduction cycle: Diet Combination (DC)-DC1-14/14 (G/L), DC2-12/16 (G/L), or DC3-9/18 (G/L). Two average pigs were used from 59 gilts farrowing in P1 and 62 sows farrowing in P2. Pigs were weighed and blood sampled at 18-24 hrs, 28, 42 and 49 days of age after birth. Piglets were challenged with a Salmonella antigen upon reaching 28 days of age and titers were determined 14 and 21 days post injection. Overall growth (0-49 days) of pigs from DC2 sows was lower ( $P < .05$ ) during P1. In P2, growth was similar for all pigs. Serum proteins (SP) in P1 were similar for all diet combinations except for a depression ( $P < .05$ ) at 28 days for DC1 pigs. No differences in SP were observed in P2. Antibody titers were not influenced by sow diet in P1. An increase ( $P < .05$ ) in titers occurred due to parity in P2. During P2, pigs from DC2 sows had lower ( $P < .05$ ) titers at 14 days post injection but titers were similar at 21 days.

CONTROL OF THE POTATO LEAFHOPPER, *EMPOASCA FABAE* (HARRIS), AND THE EFFECT ON PEANUT YIELDS. Jack W. Jenkins\* and J. C. Smith, Tidewater Research and Continuing Education Center, VPI & SU, Suffolk, VA 23437

New and standard pesticides applied to peanut (*Arachis hypogaea*) fields in Virginia were evaluated for their ability to control the potato leafhopper, *Empoasca fabae* (Harris). Leafhopper populations on test plots were monitored throughout 1975 and 1976 using a 12-inch sweep net. Grade, yield, and value data were collected from all experiments. Significant reductions of leafhopper populations were achieved with a broad range of chemicals. In many instances, the pesticidal activity of the test materials was not significantly affected by reducing their rate of application. Despite heavy leafhopper populations and injury levels during the two seasons, regression analyses demonstrated a lack of association between peanut values (dollars per acre) and potato leafhopper infestations or injury. Controlling the leafhopper did not significantly affect peanut values.

INVESTIGATIONS WITH F<sub>1</sub> HYBRID VARIETIES OF VIRGINIA DARK-FIRED TOBACCO. J. L. Jones, Southern Piedmont Center, VPI & SU, Blackstone, Virginia 23824.

Two field experiments were conducted to investigate the feasibility of utilizing F<sub>1</sub> hybrid varieties in Virginia Dark-fired tobacco production. In Experiment 1, cytoplasmic male-sterility was transferred to the variety, Va 331 by the backcross method using the flue-cured variety, Hicks, Broad-leaf (containing *Nicotiana megalosiphon* cytoplasm) as the non recurrent parent and source of male-sterility. Male-sterile Va 331, its 10 male-sterile hybrids, and their normal fertile counterparts were compared. The male-steriles were lower in yield, acre value, and plant height, and had fewer leaves than the male-fertiles.

In Experiment 2, male-sterile Va 331 was crossed as the maternal parent with eight other dark-fired varieties as pollen parents. The eight male-sterile hybrids were compared with the nine parents and male-fertile Va 331. Yields of the male-sterile F<sub>1</sub> hybrids ranged from 97 to 114% of the higher parent with a mean of all crosses of 109%. In general, the hybrids showing the greatest heterosis and largest yields did not arise from the highest yielding parents. Black Shank resistance, yield appearance, and chemical composition of the hybrids were intermediate between their parents.

PEANUT HULLS AS A SOIL AMENDMENT FOR CONR ON TATUM SILT LOAM. G. D. Jones and J. A. Lutz, Jr., Va. Poly. Inst. and State Univ., Blacksburg, Va. 24061.

Peanut hulls applied annually at the depth of 0, 1.9, 3.8 and 7.6 cm on two soil fertility levels and plowed under increased corn yields from 79 and 129 q/ha to 145 and 167 q/ha in 1975, respectively, and from 33 and 70 q/ha to 86 and 99 q/ha in 1976, respectively. Corn silage yields, 0% H<sub>2</sub>O, were increased from 7.4 and 13.0 to 15.9 and 18.4 mt/ha as the rate of hulls were increased. Corn height was increased with added rate of hulls in both years. Available soil P, K and Ca were increased with varying depth of hulls on both fertility levels. Available soil Mg was not affected and available soil P was extremely low. N and K concentration in the leaves and stover were increased with added hulls on both fertility levels, Ca was highest on the higher fertility level only, and Mg decreased as the depth of hulls was decreased on both fertility levels. Soil moisture during the growing season was 2.1% higher in 1975 and 2.7% higher in 1976 in the 0-15 cm soil depth where hulls were applied at 7.6 cm depth.



EFFECT OF BENZIMIDAZOLE FUNGITOXICANTS ON BUDBREAK, PHYTO-TOXICITY AND DUTCH ELM DISEASE EXPRESSION IN 3-YEAR-OLD AMERICAN ELMS. S. F. Justis, D. B. Janutolo and R. J. Stipes. Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

In a greenhouse study, dormant 3-year-old American elms (*Ulmus americana*) grown in 15-liter pots of Weblite were treated at two concn. (500=L and 2,500=H  $\mu\text{g/ml}$ ) of either Lignasan (LIG) or Lignasan-BLP (BLP). The trees were each drenched with 2 liters of the appropriate solution of fungicide at 0 and 9 days, and with 1 liter at 21 and 29 days. Controls were drenched with equal amounts of water. There were 8 trees/treatment. Daily observations were made for budbreak and phytotoxicity, while foliar fungicide residues were determined 45 days after the first drench. A 1:1 EtOH: Me<sub>2</sub>CO extract of 3 g of tissue/tree was analyzed via the bioassay disk-fungus agar streak method. Trees were inoculated with *Ceratocystis ulmi* 7 wks after the first drench.

A large percentage of trees treated with the fungicides exhibited an earlier budbreak than control trees. Phytotoxicity was severe on the BLP-H trees and to a lesser extent on the LIG-H trees. The lower concn. treatments caused little if any phytotoxicity. More fungicide was present in BLP-treated elm tissue than in the LIG-treated tissues. *C. ulmi* was reisolated from (1) all control trees, (2) 3 LIG-L-treated trees, (3) 1 BLP-L-treated tree and (3) none of the LIG-H- or BLP-H-treated trees.

TESTOSTERONE AND ANDROSTENEDIONE CONCENTRATIONS IN YOUNG PRENATALLY STRESSED BOARS. H. G. Kattesh, E. T. Kornegay, F. C. Gwazdauskas, J. W. Knight, H. R. Thomas and T. N. Meacham. Depts. of Animal Science and Dairy Science and Tidewater Research and Continuing Education Center, VPI&SU, Blacksburg, Va. 24061, and Suffolk, Va. 23437.

In order to determine the effects of prenatal stress on testosterone (T), libido (L) and other reproductive parameters, a total of 10 confinement reared boars, 5 from sows subjected to heat and crowding stress during mid-gestation (S) and 5 from control (C) sows were bled via indwelling vena cava catheters at weekly intervals at various ages between 166 and 208 days of age. Six boars (3S, 3C) were purebred Yorkshires (PBY) and 4 (2S, 2C) were crossbreds (XB). The weekly bleedings consisted of drawing a 10 ml sample every 30 min over a common 6 hr period (13 samples/sampling period). Overall T conc ( $\bar{X} \pm \text{SEM}$ ) were quite similar between S and C boars ( $1.64 \pm .09$  vs  $1.67 \pm .11$  ng/ml). However, least squares analysis of variance, adjusting for other parameters, indicated a significant ( $P < .02$ ) treatment effect on T conc. By adjusting the sample periods of each boar to a common point of peak T, it was found that one major peak of T, lasting 30 min, occurred over a 6 hr period. The magnitude of this peak was greater in C boars. Other parameters analyzed included T conc, L score, weight (W), health (H), initial and final hematocrit (HCTA, HCTB) and breed (B). Analysis of androstenedione conc. is in progress.

SEASONAL ABUNDANCE OF PREDATORS OF *HELIOTHIS ZEA* (BODDIE) IN SOYBEANS IN SOUTHEASTERN VIRGINIA. J. G. Knausenberger\* and W. A. Allen. Dept. of Entomology, VA Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Weekly ground cloth samples were taken of major arthropod predators of the corn earworm in soybeans in 16 fields in 1975. The data were analyzed for relative abundance information on each predator. The data were standardized by predator by field to a mean of 10 and standard deviation of 1. Analysis of variance and Duncan's multiple range test were used to compare predator abundance between times sampled and between times sampled within each field. Although predator numbers usually peaked during the season, the breadth and the time of the peak varied significantly between times and times within fields. The predators in this study were *Orius insidiosus* (Say), adults and nymphs; *Nabis roseipennis* Reuter, adults and nymphs; *Geocoris punctipes* (Say), *Geocoris uliginosus* (Say) and *Geocoris* nymphs; *Coleomegilla fuscilabris* Mulsant, adults and larvae; *Chrysopa* spp. larvae; Pisauridae; Lycosidae; Oxyopidae; Clubionidae; Thomisidae; and Salticidae. This analysis emphasizes the importance of microhabitat in the study of predator populations.

FURTHER STUDIES ON THE RESPONSE OF GESTATING GILTS TO APPLIED STRESS. J. W. Knight, H. G. Kattesh, E. T. Kornegay, F. C. Gwazdauskas and H. R. Thomas. Depts. of Anim. Sci. and Dairy Sci. and Tidewater Research and Continuing Education Center, VPI&SU, Blacksburg, Va. 24061, and Suffolk, Va. 23437.

A total of 23 gilts were bred at estrus and randomly assigned to either a stressed (S) or control (C) group. The stress consisted of heating ( $\bar{X}$  temp. =  $33.5^\circ\text{C}$ ) and crowding ( $.9\text{m}^2/\text{gilt}$ ). Gilts were placed in the stress chamber at day 21 of gestation and remained there until day 71. C gilts were housed in outdoor dirt lots and subject to normal ambient temp. All gilts were bled via vena cava puncture at 20, 21, 22, 26,  $30 \pm 1$ ,  $50 \pm 1$ ,  $71$ ,  $86 \pm 3$  and  $111 \pm 1$  days of gestation. Corticoid (Cort) conc. were signif. ( $P < .0001$ ) greater in C vs. S gilts at all stages of gestation. There was an initial depression of basal cort. levels in the S gilts, indicating a stress response, but this depression was not maintained. Rectal temp. was not significant ( $P > .10$ ) different between treatments. C gilts tended to have larger litters, heavier pigs and better post-natal survival of pigs but these differences were not significant ( $P > .10$ ). It is concluded that the stress applied in this study was not severe enough to result in any significant reduction in performance.

CALCIUM AND PHOSPHORUS REQUIREMENT OF FINISHING SWINE AS INFLUENCED BY SEX AND GROWTH RATE. E. T. Kornegay and H. R. Thomas. Dept. of Animal Science and Tidewater Research and Continuing Education Center, VPI and SU, Blacksburg, Va. 24061.

Meat-type pigs (192) were fed (4 pigs/pen) by sex (barrows and gilts) and growth rate groups (fast and slow) 14% protein diets with the following dietary calcium (Ca) and phosphorus (P) combinations in the finishing phase (110 to 230 lb): 1) NRC Ca and P, 2) 25% higher than NRC Ca and P, 3) NRC Ca and 25% higher than NRC P, 4) NRC Ca and 25% lower than NRC P. Growth rate from birth was calculated when the pigs were about 7 weeks of age and all pigs were fed NRC nutrient levels until they weighed about 110 lb when dietary treatments were randomly assigned. Barrows ate more and grew faster ( $P < .01$ ) than gilts, but were only slightly less efficient. Pigs in the fast as compared to the slow growth rate group ate more ( $P < .01$ ), but were less ( $P < .01$ ) efficient. There appeared to be no difference in the gain of the barrows fed the various diets; however, gilts fed diet 2 had the highest ( $P < .05$ ) daily gain and gilts fed diet 4 had the lowest ( $P < .05$ ) daily gain. Feed/gain was poorest for pigs fed diet 4. Feet and leg and pad scores were not influenced by any of the dietary treatments. Serum P level was lowest ( $P < .05$ ) for pigs fed diet 4. Breaking strength and percent bone ash (dried fat free) of the metacarpals were lowest ( $P < .01$ ) for pigs fed diet 4.

OVIPOSITION PREFERENCE AND SURVIVAL OF IMPORTED CABBAGEWORM ON FALL-PLANTED CABBAGE HYBRIDS IN SOUTHEASTERN VIRGINIA. M.A. Latheef and R.D. Irwin. USDA-CSRS Research Program, Virginia State College, Petersburg, Va. 23803.

Oviposition preference and survival of the imported cabbageworm, *Pieris rapae* (L.), on hybrid varieties of savoy, smooth green and purple cabbage were investigated at Petersburg, Va. A discriminatory ovipositional response was detected; however, such a discrimination was not perfect with occurrence of temporal variation in oviposition rate. Foliage color did not affect egg laying, but there was significant correlation between plant size and oviposition rate. Larval populations did not reflect egg density. More eggs perished on savoy than on either smooth green or purple. (Supported by CSRS Grant #416-15-69)

PERIPARTURIENT MILK PROGESTERONE CONCENTRATIONS. M. M. Lewter,\* M. DeSilva,\* F. C. Gwazdauskas, R. M. Akers,\* C. W. Heald\* and M. L. McGilliard.\* Dept. Dairy Sci., Va. Polytechnic Inst. and S.U., Blacksburg, VA 24061.

Milk samples were collected twice daily from randomly selected udder halves of seven Holstein cows from 18-0 days prepartum to two days postpartum. The remaining halves were un milked until two days postpartum. Milk lactose, fat and casein were measured for five of the seven cows. Milk progesterone was quantified by Competitive Protein Binding radioassay from two iso-octane extracts of 1 ml of mammary secretion. Statistical analysis of data was performed by univariate and multivariate regression analysis. Milking prepartum had no significant effect on milk progesterone ( $P > .10$ ) or progesterone content ( $P > .10$ ). However, prepartum milking significantly increased lactose ( $P < .01$ ) and casein content ( $P < .01$ ). Progesterone content was elevated between initial milkings and days postpartum ( $P < .01$ ). Progesterone content increased from 696 ng on day -18 to 2137 ng two days postpartum. Progesterone content was correlated with days prepartum (-.30), milk volume (.27), lactose (.25) and fat (.26). Though progesterone is thought to inhibit initiation of synthesis of various milk components, our data do not indicate this.

PREDICTION EQUATIONS FOR CENTERS OF GRAVITY AND MOMENTS OF INERTIA FOR LOBLOLLY PINE STEMS. T.B. Lynch\*, and T.A. Max\* School of Forestry and Wildlife Resources, Va. Polytechnic Inst., Blacksburg, Va. 24060

Equations that predict centers of gravity and moments of inertia for loblolly pine stems were developed. Independent variables used were diameter at breast height and total height. Data used was from a loblolly pine yield study. The best prediction equations were chosen from a group of logical candidate equations on the basis of  $r^2$ ,  $s_y^2$ ,  $x^2$ , the  $C_p$  statistic, and tests on an independent data set.

DEVELOPMENT OF A THEORETICAL ECONOMIC INJURY LEVEL FOR THE MEXICAN BEAN BEETLE ON SOYBEANS. T. J. McAvoy\* and J. C. Smith. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The effect of defoliation on yield was established by hand defoliating full season York variety soybeans during 1975 and 1976 at Suffolk, Va. Rates of 0, 33, 67, and 100% defoliation were made at the six trifoliate (V-7), full-bloom (R-2), pod-set (R-4), and pod-fill (R-6) growth stages. Combining the data from 1975 and 1976, relationship between percent defoliation (X) and percent yield loss (Y) expressed as 2nd degree equations for growth stages V-7, R-2, R-4, and R-6 was:  $Y = .101X + .003X^2$ ;  $Y = -.459X + .008X^2$ ;  $Y = -.389X + .012X^2$ ; and  $Y = .056X + .002X^2$ , respectively. The total leaf surface area/plant was found to be 601.9cm<sup>2</sup>, 2132.5cm<sup>2</sup>, 2820.7cm<sup>2</sup>, and 2428.7cm<sup>2</sup> for growth stages V-7, R-2, R-4, and R-6, respectively. Mean foliage consumption for the Mexican bean beetle (MBB) under a rearing temperature of 20.4°C and 25.8°C was found for the 1st, 2nd, 3rd, and 4th instar and adult/24 hours to be .51cm<sup>2</sup>, 1.73cm<sup>2</sup>, 4.75cm<sup>2</sup>, 8.78cm<sup>2</sup>, and 3.15cm<sup>2</sup>, respectively.

The economic injury level (EIL) was computed from a deductive mathematical model. With a management cost of \$4.00/acre; a market value of \$6.00/bu; and a projected yield of 25 bu/acre a yield loss of 2.7% can be tolerated. A MBB population/plant (EIL) of 3.3, 5.7, 6.5, and 13.6 at the beginning of growth stage V-7, R-2, R-4, and R-6, respectively, will cause 2.7% yield loss.

STORED TOBACCO INSECT CONTROL: PRESENT AND FUTURE J. S. Long, Philip Morris U.S.A., Research Center, P. O. Box 26583, Richmond, VA. 23261

A general review of currently employed methods for controlling the cigarette beetle, *Lasioderma serricorne* (F.), and the tobacco moth, *Ephestia elutella* (Hübner) on stored tobacco will be given. The effects of the Environmental Protection Agency's actions against insecticides used by industry will be discussed and a summary of promising insect control procedures for future use on stored tobacco will be presented.

TROPICAL AGRICULTURE. P. Howard Massey, Jr., Professor of Horticulture and Associate Dean, College of Agriculture & Life Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

Significant problems and special opportunities to increase food production in tropical environments were identified. Problems discussed included: wide variations in soil type and levels of nutrients, moisture, temperature; excessive light, wind and relative humidity; and prevalence of insects, diseases, weeds and rodents.

Special opportunities identified included: genetic engineering -- plant varieties developed for maximum production in tropics; special production technology packages designed to utilize the natural advantages of warm temperature, abundant sunlight, moisture and hand labor.

A primary thrust in assisting developing nations in food production should be designed to help farmers help themselves. Economic incentives must be assured to farmers to stimulate additional food production.

A COMPARISON OF METHODS OF PREDICTING TREE DIAMETER AT BREAST HEIGHT USING STUMP DIAMETER AND STUMP HEIGHT. M. Mengak and A. R. Tipton, School of Forestry and Wildlife Resources, VPI & SU, Blacksburg, Virginia 24061.

Many wildlife studies have dealt with assessing the quality of wildlife habitat after different silvicultural treatments. As part of a study to analyze browse availability and wildlife utilization on a selectively thinned upland mixed oak stand there was a need to determine the precut basal area of the stand. 948 trees within the study area were measured for stump height, stump diameter and diameter at breast height (dbh). Three regression models were developed to predict dbh using this data. Basal areas for the trees were calculated using the predicted dbh from the models. There was no significant difference in the basal areas calculated from these models. A multiple linear regression model was used to predict dbh for 602 stumps in the study area. Basal area for the stumps was calculated. Total precut and residual basal area for the study site was determined.



INTRASPECIFIC VARIATION IN HETERODERA GLYCINES. L.I. Miller, Dept. of Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Comparisons of different characters of 11 isolates of *Heterodera glycines*, reared on *Glycine max* 'Lee' at one location, demonstrated that each of the isolates was morphologically different. Even though the morphological differences were statistically significant they were not considered to be a sound basis for distinguishing the isolates as sub-species because the average measurement for each character varied clinically and all of the ranges of measurement for each character overlapped. Each amphimictic isolate interbred and formed fertile hybrids in all the 55 possible crosses, which indicated that the isolates are reproductively compatible. Each of the isolates also proved to be a distinct race, differentiated by its ability to develop egg-bearing females on eight lines of *G. max*. Populations derived from hybrids formed between crosses of single larva of 2 isolates were like one or both of the parents, intermediate between both parents, or exceeded the limits exhibited by the parents in their ability to reproduce on a common host. Some of the populations derived from inbreds from crosses of single larva of a single cyst also exhibited transgressive variation. For example, the Miss.1 isolate was unable to reproduce on *G. max* 'Peking' and P.I. 90763, but some of the populations derived from inbreds from a single cyst were able to reproduce on these two plants. It is apparent that a wide range of genetic diversity is exhibited by *H. glycines* and that factors controlling parasitism are complex.

CORKY EXCRESCENS OF THE STEMS OF *CISSUS QUADRANGULARIS* INFECTED WITH A ROOT-KNOT NEMATODE, *MELOIDOGYNE* SP. Lorraine S. Ormrod\* and L. I. Miller, Dept. of Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Recently a tan colored excrescens of the above ground stem segments of *Cissus quadrangularis*, infected with a species of *Meloidogyne*, was observed in plants from a greenhouse in Williamsport, Pennsylvania. *C. quadrangularis* is a dark green, four-winged, succulent species of the Vitaceae which resembles a spineless cactus. Feeding of the nematode in the cortical and parenchymatous tissues stimulates the formation of giant cells in the interfascicular area between the discrete vascular bundles. The second stage larvae and the enlargement of the sedentary stages of the larvae after each molt causes injury and abnormal development of all tissues from the parenchyma to the periphery of the stem. Infected areas of the stem exhibit numerous disorganized vascular elements near the body and egg masses of the females and a corky excrescens at the stem surface. Root galls induced by *Meloidogyne* spp. have previously been reported in several species of Vitaceae. This is believed to be the first report of a root-knot nematode infecting and causing a corky excrescens of the aerial parts of a plant species of the Vitaceae.

NC-95 FLUE-CURED TOBACCO AS A HOST OF *GLOBODERA PALLIDA*. Diana M. Parrott\* and L. I. Miller, Dept. of Nematol., Rothamsted Exp. Sta., Harpenden, England AL5 2JQ and Dept. of Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Experiments in the glasshouse at the Rothamsted Experimental Station, England were initiated in the summer of 1974 to determine whether the Cadishead *G. pallida* Pa3 and Dunminning *G. pallida* Pal populations could reproduce on 'NC-95' flue-cured tobacco (*Nicotiana tabacum*). Neither population reproduced on tobacco but did so on 'Arran Banner' potato (*Solanum tuberosum*). In a similar experiment in the spring of 1975, however, a few females of the two nematode populations were produced on tobacco whereas many were produced on potato. Additional trials to confirm these findings are needed since it is important to know whether *G. pallida* is a potential parasite of flue-cured tobacco as reported for several isolates of *G. rostochiensis* in Venezuela by J. A. Meredith. (Aided by NATO Research Grant 686).

CONTROL OF FUSARIUM WILT OF TOMATO WITH SYSTEMIC BENZIMIDAZOLE FUNGITOXICANTS. W. R. Okie and R. J. Stipes. Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Benzimidazole fungitoxics were assayed preventively and curatively in the control of Fusarium wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici*. Plants were grown in Weblite and Spasoff's mix, artificially inoculated with the pathogen and treated by a soil drench with 500 µg/ml benomyl, methyl-2- benzimidazolecarbamate (MBC), MBC·HCl or MBC·H<sub>3</sub>PO<sub>4</sub>. Chemicals were applied one week before or after inoculation or at the time of symptom expression. All compounds, especially benomyl, were phytotoxic at the rate used. Disease control was evaluated by external symptoms, height, weight, vascular discoloration and the presence of the pathogen in the stem. Treatment one week before or after inoculation gave complete control, whereas treatment at symptom expression gave less complete control. The chemicals were fungicidal in all treatments except for treatments using MBC·H<sub>3</sub>PO<sub>4</sub> and MBC·HCl at symptom expression on Weblite in which case they were fungistatic.

LABORATORY STUDIES ON THE MASS REARING OF *OIDAEMATOPHORUS MONODACTYLUS* ON HEDGE BINDWEED. M. P. Parrella\* and L. T. Kok, Dept. of Entomology, VPI and SU, Blacksburg, VA 24061

Continuing studies on the plume moth, *Oidaematophorus monodactylus* (L.) (Lepidoptera: Pterophoridae) have shown that it can be successfully reared on hedge bindweed (*Convolvulus sepium* L.) in the laboratory throughout the year. Optimum rearing conditions were 23.9 ± 1°C, 60-80% RH, and 15-h photoperiod. At these conditions, each generation takes about 4 weeks. As the newly emergent moths oviposit readily within 48 hours, 10-12 generations may be reared annually. A large laboratory colony can thus be maintained and used in a program of inundative releases for the suppression of hedge bindweed. An estimate of the direct costs of rearing 10,000 moths for a single June release in southwestern Virginia averaged less than 0.80¢ per insect. This estimate was based on colony initiation using field collected larvae in the previous summer, maintenance of a minimal population in the fall and winter, and subsequently increasing the population in the spring. This estimate is on the high side since 30% are non-recurring expenses and costs could be reduced with further improvements in the propagation techniques and the development of an artificial diet.

USE OF PARASITES FOR GYPSY MOTH CONTROL IN VIRGINIA. P. B. Schultz\* and L. T. Kok. Dept. of Entomology, VPI and SU, Blacksburg, Va. 24061

The gypsy moth, *Porthetria dispar* (L.), is a potential threat to Virginia's oak forests. The larvae are capable of defoliating vast acreages of forested land, resulting in reduction of normal growth and frequently, mortality of the trees. In addition, watersheds, recreational areas, and the aesthetic value of land are also affected.

The importation of parasites and predators of the gypsy moth began soon after the insect became a major problem in Eastern U.S.A. The parasites do not prevent major outbreaks of the gypsy moth but may lengthen the period between outbreaks. In Virginia, the mass rearing and release of parasites was initiated in 1972 by the Virginia Department of Agriculture and Commerce. Since the gypsy moth was not present at that time (and only adult males have been trapped since then), the objective is to establish the parasites on alternate native hosts. Two larval parasites, *Compsilura concinnata* and *Meteorus pulchricornis*, and two pupal parasites, *Brachymeria intermedia* and *Coccygominus turionellae*, are currently being reared on *Galleria mellonella*. Releases of the parasites in areas with known populations of alternate hosts were evaluated by subsequent collection of alternate hosts and *G. mellonella* larvae and pupae. Although native parasites have been collected, no recoveries of the released species have been made.

<sup>1</sup>-*Lymantria*



EFFECT OF TOBACCO NUTRITION ON THE OCCURRENCE OF INSECT PESTS. P. J. Semtner\* and M. Rasnake.\*Southern Piedmont Center, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 23824

Tobacco insect populations were determined at times of peak abundance for three tobacco types fertilized at different nutrient levels. The experiment was conducted near Blacksburg, Va. during 1976 on land that had been out of agricultural production for ca. 35 yrs and contained low levels of phosphorus. Low, medium and high levels of nitrogen, phosphorus and potassium were tested in 27 different combinations.

Green peach aphid, *Myzus persicae* (Sulzer), populations decreased with increasing rates of nitrogen and phosphorus fertilization, while the medium rate had the lowest aphid populations among the potassium nutrient levels. Tobacco flea beetle, *Epitrix hirtipennis* (Melsch.), populations and their damage decreased slightly and with increasing rates of nitrogen. Tobacco hornworm, *Manduca sexta* (L.), populations and damage decreased with increasing levels of phosphorus fertilization, while their damage increased slightly with increasing levels of nitrogen and potassium.

MODELING THE HYDROLOGIC IMPACT OF SOUTHERN PINE BEETLE ATTACKS. D. G. Shore\* and W. A. Leuschner, Dept. of Forestry and Forest Products, VPI & SU, Blacksburg, VA 24061

Modeling and quantifying hydrologic impacts due to southern pine beetle (*Dendroctonus frontalis*, Zimm.) (SPB) attack are important in developing economic decision guidelines for various levels of SPB control. Hydrologic models describing SPB impacts on watersheds do not exist, therefore, existing models must be extended to the SPB as well as the southern U.S. Hydrologic models developed in Arkansas, Kentucky, and North Carolina have shown the greatest applicability. We desired to measure impacts on water yield, erosion, dissolved nutrients, and water temperature, but water yield is the only variable the models are sensitive enough to measure. The models simulate daily and/or monthly water yields and contain among others, precipitation and vegetative cover inputs. These two inputs will be manipulated to simulate the widest possible range of effects that could be caused by an SPB epidemic. The impacts that cannot be simulated with existing models will be dealt with in a qualitative fashion. (Funded by CSRS Research Agreement # 680-15-3).

TEMPORAL AND SPATIAL DISTRIBUTION OF EGGS OF THE POTATO LEAFHOPPER, *EMPOASCA FABAE* (HARRIS) IN ALFALFA. D. E. Simonet and R. L. Pienkowski, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The distribution of eggs of the potato leafhopper, *Empoasca fabae* (Harris) was studied in two alfalfa fields in Montgomery County, Va. Since *E. fabae* oviposits in the stem and petiole of alfalfa a lactophenol-acid fuchsin stain was used to clear stems and count eggs. Samples were collected throughout June, July, and August in 1976 to determine the relative seasonal abundance of eggs. Measurements were made to determine the oviposition pattern within the plant, this was related to the season and the growth stages of the alfalfa. Egg counts obtained were used to determine the distribution pattern of eggs within the field, and the sample size necessary to estimate the number of eggs present in the field. This technique is considered to be a reliable method of determining the density of eggs of the potato leafhopper. However, the time involved in clearing stems and counting eggs for the large sample sizes necessary to obtain reliable estimates of egg numbers at low densities precludes its use as a general sampling method.

CONTROL SCHEMES FOR TWOSPOTTED SPIDER MITES ON PEANUTS. J. C. Smith and R. W. Mzingo. Tidewater Res. & Cont. Ed. Ctr., Va. Polytechnic Inst. & State Univ., Suffolk, Va. 23437.

Twospotted spider mites (*Tetranychus urticae* Koch) have been successfully controlled on peanuts with selected foliar sprays or with certain systemic acaricides. Aldicarb (Temik) control of spider mites was generally excellent when granules were placed either in the seed furrow or as a band treatment at planting. Split applications (planting + pegging) of aldicarb gave superior systemic control, whereas split applications of phorate (Thimet) or disulfoton (Disyston) or planting-time applications of carbofuran (Furadan) showed only slight systemic control of spider mites.

Spray pattern, nozzle arrangement, pressure and volume were varied in a 1976 experiment employing dicofol (Kelthane) and monocrotophos (Azodrin). Dicofol was superior in efficacy, and there was a trend for better control with higher volumes, but no trends were found for spray pattern, nozzle arrangement or pressure of application.

Corrective (control) spray tests showed good to excellent control with Plictran, Carzol, Kelthane, Omite, Galecron and Azodrin.

Carbaryl (Sevin) + Bravo and Carbaryl + Fungisperse tank mixes developed more severe spider mite infestations than carbaryl + Duter or carbaryl + Benlate mixtures. Azodrin-, Kelthane-, Carzol- or Plictran + Benlate mixtures were free of spider mite injury.

THE INFLUENCE OF SELECTED HERBICIDES ON THE SENSITIVITY OF FLUE-CURED TOBACCO TO OZONE. Shi-Jean Sung\* and L.D. Moore. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Two flue-cured tobacco cultivars NC 88 and Coker 319 were grown in greenhouse. Four weeks after germination, the seedlings were transplanted into a soil: weblite: peat mix (1:1:1). Treatment with herbicide was as follows: Enide 50W<sup>®</sup> at 3 oz/1000 sq ft, was diluted in water and applied to the base of each plant immediately after transplanting. Paarlant<sup>®</sup> at 2 pt/acre, was incorporated into soil mix one week before transplanting. Tillam<sup>®</sup> at 2 2/3 qt/acre, was incorporated into soil mix immediately before transplanting. Two weeks after transplanting, half of the plants in each treatment were fumigated with ozone, at 15 pphm/2.5 hr, on four successive days. One week later, the plants were harvested. Ozone injury was rated as percentage weather fleck for each plant. The excised plants were oven-dried at 75 C for 48 hours, ground to pass a 20-mesh screen and analyzed for reducing sugar, total nonstructural carbohydrate and nicotine. Paarlant<sup>®</sup> reduced ozone sensitivity more than Tillam<sup>®</sup> yet both Paarlant<sup>®</sup> and Tillam<sup>®</sup> reduced ozone sensitivity of Coker 319 equally. Ozone fumigation reduced the reducing sugar contents of NC 88 and Coker 319. Paarlant<sup>®</sup> and Tillam<sup>®</sup> treated NC 88 had more reducing sugar than nonherbicide-treated NC 88. Coker 319 had less reducing sugar and was more ozone sensitive than NC 88 under the conditions of this study.

ROOT AND TOP GROWTH OF KENTUCKY BLUEGRASS, *POA PRATENSIS*, AT DIFFERENT TEMPERATURES. L. H. Taylor. Dept. of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Thin layer sod samples of 36 Kentucky bluegrass cultivars and selections were grown over a nutrient solution in growth chambers at cool and warm day and night temperatures (approximately 23-16°C and 34-27°C, respectively) and clipped at weekly intervals for a period of 5 weeks. At the end of this period, turf appearance and new root production were evaluated and the total roots produced by the sod samples were measured. Top growth production, initially greatest at the higher temperatures, was markedly more at the lower temperatures by the end of the experimental period. Turf appearance was superior at the lower temperatures. Lower temperatures also resulted in greater initiation of new roots and more total root growth, and for these characteristics the temperature regime x cultivar interactions were significant.



MINERAL DETECTION VIA ENERGY DISPERSIVE X-RAY ANALYSIS - A USEFUL TECHNIQUE FOR NUTRITIONAL STUDIES. J. T. Trumble\* and L. T. Kok. Dept. of Entomology, VPI and SU, Blacksburg, Va. 24061

Using the EDAX International attachment (energy dispersive analysis of X-rays) to the AMR model 900 scanning electron microscope at V.P.I. and S.U., the mineral contents of artificial diets for the thistle weevil Ceuthorrhynchidius horridus (Panzer) were compared to mineral traces from a musk thistle leaf (Carduus nutans L.). A magnification of 12x produced a sample area of 3 square mm by 150 Å in depth. Because the scanning electron microscope operates in a vacuum, artificial diets and plant material were lyophilized for 24 hours prior to examination. Results showed only minor variation in mineral contents and indicated that the majority of minerals present in the synthetic media were not from the thistle leaves incorporated into the diets. Repetitive sampling demonstrated that diet mixing procedures were adequate. This technique, because of limitations of the equipment, is not accurate for detecting minerals with atomic numbers lower than 12. However, even with this restriction, energy dispersive X-ray analysis could be useful in assessing the purity of diet constituents; a critical factor in nutritional studies.

A METHODOLOGY FOR ESTIMATING THE ECONOMIC IMPACT OF SOUTHERN PINE BEETLE ON RESERVOIR RECREATION. R.L. Young\* and W. A. Leuschner, Dept. of Forestry and Forest Products, VPI & SU, Blacksburg, VA 24061.

A southern pine beetle control program may produce benefits by preventing tree mortality and thus maintaining a higher value of forest products, such as timber, recreation, water, wildlife, grazing, and aesthetics. The potential recreation benefits should be estimated for inclusion in total program benefits. A demand function was estimated for the recreation produced at a recreation site. The function includes variables measuring on-site activities and scenery, cost of recreating, substitute recreation sites, and socio-economic variables of the recreators' origins. The scenic variables include a measure of the amount of southern pines on the site. The demand curve for recreation at the site was estimated and the total social value estimate is the area under this curve. A southern pine beetle attack is simulated by reducing the value of the pine variable and re-estimating the social value of recreation. The difference between recreation values with and without an attack are the recreation damages and program benefits are the amount of these damages which would be prevented. Various levels of control and beetle attacks can be simulated. The methodology may be used throughout the South and for estimation of the recreation benefits of other disease and insect control programs. (Funded by CSRS Research Agreement #680-15-3).

## Section of Astronomy, Mathematics, and Physics

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

TWELVE-IN-ONE PHYSICS DEMONSTRATION. D. Rae Carpenter, Jr., Virginia Military Institute, Lexington, VA 24450

A piece of physics apparatus can often be used for several demonstrations. One demonstrated and described in this paper has found exceptionally wide usage at VMI. It consists of a capacitor type fractional horsepower AC motor with a 30 cm diameter disk mounted to the motor shaft. Twelve different demonstrations in six different fields of physics can be illustrated using this motor as follows:

- Mechanics - conservation of Angular Momentum, Gyroscopic Effect and Parallel Axis Concept
  - Fluids - Bernoulli's Principle
  - Waves - Chladni Plate and Doppler Effect
  - Magnetism - Magnetic Levitation and Magnetic Braking
  - Electricity - Back Emf, Torque vs Motor Current, Relative Independence of Line Voltage and Motor Speed
  - Light - Mechanical Addition of Colors
- Auxilliary apparatus, mostly simple and inexpensive, is used including a strong ring magnet, lazy susan, violin bow, variac with AC ammeter and voltmeter and strobe light.

DEMONSTRATION OF PHASE AND AMPLITUDE RELATIONSHIPS IN A SERIES LRC CIRCUIT USING A SINGLE CHANNEL OSCILLOSCOPE AND MULTIPLEXED OPERATIONAL AMPLIFIERS.

F. P. Clay, Jr., and R. L. Kernell, Physics & Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508

Simultaneous display of  $V_R$ ,  $V_L$ ,  $V_C$ , and  $V_{gen}$  waveforms on a single channel oscilloscope can be achieved by using differential amplifiers to derive separate ground referenced signals from each component in a series LRC circuit. The outputs from these differential amplifiers accurately retains the amplitude and phase information. These waveforms are then time multiplexed, so that four periods of each waveform are presented at the multiplexer output in turn. This multiplexed output is fed into the y-input of the scope and a trigger derived from the  $V_R$  waveform is used to synchronize the time base at one fourth the generator frequency. The composite scope pattern then yields separate waveforms for  $V_L$ ,  $V_R$ ,  $V_C$ , and  $V_{gen}$ , all displayed on a common axis with accurate amplitude and phase information retained and where the  $V_R$  waveform becomes the reference phase. The display is stable for wide variation in generator frequency.

CHARACTERISTICS OF ION BEAMS GENERATED BY A MULTIDIPOLE SOURCE. R. D. Collier\*, K. N. Leung, G. R. Taylor, and R. E. Kribel; Department of Physics, Madison College, Harrisonburg, Virginia 22801

Hydrogen plasma produced by DC discharge contains different ion species namely  $H^+$ ,  $H_2^+$  and  $H_3^+$ . A mass spectrometer was built to analyze the relative abundance of the different ion species extracted from a 7 liter multidipole source. It was found that the beam consists of approximately 97% molecular hydrogen, of which either the diatomic ( $H_2^+$ ) or the triatomic ( $H_3^+$ ) can be maximized by varying the neutral pressure. Different techniques have been attempted to increase the amount of atomic hydrogen ( $H^+$ ) which is always desirable in neutral beam injection of tokamak plasmas.

TWENTY YEARS OF COMPUTING IN NUCLEAR DESIGN, P. N. COLPO\*, Nuclear Power Generation Division, Babcock and Wilcox Co. Lynchburg, Virginia 24505.

Nuclear Reactor Steam Systems and Computers, to a great degree, have grown and developed together. More particularly, the growth and development of Computer Technology over the past 20-25 years has made it possible for Reactor Technology to grow and develop, while on the other hand, the need for greater and greater computing power required to perform systems simulations has had a degree of influence in the development of Computer Technology.

Over the past twenty years computing hardware has progressed from drum storage computers such as the IBM-650 and the Datatron 205 to computers such as the CRAY I and the Texas Instruments ASC - Advanced Scientific Computer which employ parallel processing and pipelining concepts. Nuclear Steam Systems have progressed from 150-250 megawatt reactors such as Shippingport and Indian Point I to the 1200 megawatt systems which are being marketed today. Reactor simulations have progressed from one-dimensional core analyses to three dimensional optimization studies and from one node transient analyses to the sophisticated, multi-node analyses for system response to transient conditions. It appears that the increased availability of economically competitive computing capacity will inevitably lead to a greater demand for more detailed computer simulations.

REACTION COORDINATE THEORY OF CHARGE EXCHANGE IN THE  $HD^+$  SYSTEM. J. B. Delos\*, Physics Dept., William and Mary, and W. R. Thorson\*, Chemistry Dept., Univ. of Alberta.

Theoretical studies of slow atomic collisions normally begin with the expansion of the wave function into Born-Oppenheimer basis functions. But when this theory is applied to "isotopic" systems such as  $H^+ + D \rightarrow H + D^+$ , one finds that electronic states of different parity are strongly coupled in a way that cannot be physically realistic. The problem is resolved by defining a new coordinate system that varies smoothly between the reactant and product channels. When the full wave function is expanded into a complete set of electronic states that is defined in the new coordinate system, the resulting coupled equations contain new terms, one of which cancels the fictitious parity-violating coupling. The new terms will be important for most processes involving charge exchange at large inter-nuclear distances.

THE EXISTENCE OF WAKES IN STOKES FLOW. J. M. Dorrepaal\*, Dept. of Math & Comp. Sci., Old Dominion Univ., Norfolk, Va. 23508

The Navier-Stokes equation describes the motion of a viscous incompressible fluid. Consider a fluid of infinite extent which flows past a finite fixed obstacle. Far from the obstacle the flow is that of a uniform stream. If the obstacle is small, the fluid highly viscous and the flow slow, the Navier-Stokes equation simplifies to the Stokes equation. The flow which this equation describes is called a Stokes flow.

The literature contains solutions of many different Stokes flow problems. Most of these are concerned with the drag and torque which the obstacle experiences and until recently little attention has been paid to the flow's streamline diagram. Perhaps it has been felt that such streamline patterns would be uninteresting because the Stokes flows past bodies like the sphere and ellipsoid of revolution reveal nothing unusual. Recently however techniques have been devised which solve the Stokes equation for flows past bodies with more involved geometries and these have produced some strikingly new streamline patterns.

A case in point is the Stokes flow past the spherical cap. In this paper the streamline patterns for axisymmetric and asymmetric flows past a spherical cap are presented and the existence of Stokesian wakes is established. Geometric features which contribute to the formation of these wakes are also discussed.

PLASMA DENSITY MEASUREMENTS BY RESONANCE PROBES. D. G. Fitzsimons\*, K. N. Leung, G. R. Taylor, and R. E. Kribel. Department of Physics, Madison College, Harrisonburg, Virginia 22801.

Plasma density measurements are difficult to obtain by Langmuir probe characteristics when the density falls below  $10^8$  ions/c.c. (such as plasma in the ionosphere). Different techniques have been developed to measure low plasma densities<sup>1</sup>, of which the rf resonance probe method appears to be the simplest. A very fast rising pulse is applied to a plane probe immersed in a multidipole plasma. The resonance frequency of the oscillations produced at the probe sheath is then measured by a sampling oscilloscope. Plasma density obtained by this method compares well to data obtained from Langmuir probe characteristics.

<sup>1</sup>R. S. Harp and F. W. Crawford, J. Appl. Phys., **35**, 3436 (1964)

CHARACTERISTICS OF THE MULTIDIPOLE M-III DEVICE. T. C. Gillett\*, J. A. Howell\*, J. A. Rarick\*, K. N. Leung, and G. R. Taylor; Department of Physics, Madison College, Harrisonburg, Va. 22801

A simple D. C. discharge plasma device has been constructed from a 7.5 liter stainless steel vessel (20 cm diam., 24 cm long) with an external system of permanent magnets (max. B  $\approx$  1.7 KG). The characteristics of this device are presented, including plasma uniformity, primary electron density, plasma density, and electron temperature.



ESTIMATION OF ACTUARIAL FUNCTIONS ARISING IN COAL MINE VALUATION. H. W. Gould, Dept. of Mathematics, West Virginia University, Morgantown, W. Va. 26506

We evaluate and prove seven limits involving generalized Lambert series. The simplest of these is Theorem 1. For all real  $i_s > 0$ ,  $i_p > 0$ , then

$$\lim_{n \rightarrow \infty} A_n = (1 + i_p)/i_p^2,$$

where

$$A_n = \sum_{k=0}^{n-1} \frac{(1 + i_p)^{-k}}{i_p + \frac{i_s}{(1 + i_p)^{n-k-1}}}.$$

Here  $i$  is a speculative interest rate,  $i_s$  is a sinking fund rate,  $n$  is the number of years life of the mine, and  $A$  is used in a calculation of the value of the mine. The other sums involve an adjustment for future change of royalty rate so that the classical Hoskold formula (in use since 1877) may be applied to non-producing property. The formulas appear in a new valuation method due to Donald M. Bondurant (thesis, engineering of mines, W. Va. Univ., 1974) allowing a better method of figuring ad valorem tax on mines. The method requires quick estimates such as given here in order to allow handy application. A handbook of tables is being published to make the results accessible to valuation engineers.

ELECTRONIC SPECTROSCOPY AT STEWARD OBSERVATORY 90" TELESCOPE. K. Hege, Physics Dept., Hollins College, Roanoke, VA. 24020 and G. Gilbert\* and J. Geary\*, Steward Observatory, Tucson, AZ. 85721.

Use of Reticon photodiode arrays in low-level light detection applications will be described. Limits on performance at various conditions, including operation at reduced temperature (100K) as well as with photo-electronic light amplification (image intensifiers) will be discussed. Typical spectroscopic results obtained at the Steward Observatory 90 inch telescope at Kitt Peak will be shown. (Supported in part by National Science Foundation)

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PION ABSORPTION BY DEUTERONS. R. H. Hackman, Department of Physics, Hollins College, Hollins College, Va. 24020

The pion-deuteron absorption process is important because it is the simplest example of an inelastic pion-nucleus reaction. An understanding of the two-nucleon absorption process is essential to an understanding of pion absorption by more complex nuclei. Recently the problem has taken on a new dimension as a testing place for proposed models for the off-shell behavior of the elastic  $\pi N$  scattering amplitude. The reaction cross-section is quite sensitive to how fast the elastic  $\pi N$  t-matrix decreases as it is taken off-shell (Goplen *et al*, Phys. Rev. Letters **32**, 1012 (1974)). The pion-deuteron absorption process thus has an added significance, since knowledge of the off-shell behavior of the  $\pi N$  elastic scattering amplitude seems essential to the analysis of pion-nucleus interactions.

The present work applies field theoretic techniques to this problem. The standard LSZ reduction technique and a truncated intermediate state expansion are used to develop a set of coupled, inhomogeneous integral equations describing the pion-deuteron interactions. In the single particle impulse approximation the inhomogeneous term can be shown to consist of the first two terms of a multiple scattering series expansion. Although the development of the inhomogeneous term resembles a multiple-scattering approach, all higher order rescattering corrections are formally summed in the final result. The resulting coupled equations are being investigated numerically.

ELECTROSTATIC CONFINEMENT OF PLASMA IONS. J. A. Howell\*, K. Saadatmand\*, G. R. Taylor, R. E. Kribel, and K. N. Leung. Department of Physics, Madison College, Harrisonburg, Virginia 22801.

It has been shown that primary electrons are confined very efficiently by the cusp field of the multidipole device.<sup>1,2</sup> The plasma potential in this type of device can be made negative by injecting primary electrons with energy lower than the ionization potential energy of the neutral gas. Plasma density increases when the potential becomes negative with respect to the anode surface.

<sup>1</sup>K. N. Leung, T. K. Samec, and A. Lamm, Phys. Lett. **A51**, 490 (1975).

<sup>2</sup>K. N. Leung, R. E. Kribel, and G. R. Taylor, J. Appl. Phys. **47**, 5245 (1976).

OSCILLATIONS OF A HANGING CHAIN. W. H. Ingham; Department of Physics, Madison College, Harrisonburg, Va. 22801

Modes of oscillation of a uniform hanging chain are discussed, and a simple apparatus for exciting various modes is demonstrated. It is pointed out that the phrase "rotating chain" is a misnomer. Features exhibited by this system (and not, for example, by a uniform stretched spring) are described. Numerical results on mode frequencies and patterns, based on a minicomputer analysis, are presented. As time permits, transients, energy transfer, and large-amplitude motions will be discussed.

RATE OF IONIZATION OF NEUTRALS BY A THERMAL DISTRIBUTION OF ELECTRONS. W. H. Ingham, K. N. Leung, R. E. Kribel, and G. R. Taylor; Department of Physics, Madison College, Harrisonburg, Va. 22801

Rates have been computed for ionization of the noble gases He, Ne, Ar, Xe, and Kr by a Maxwellian electron gas. Graphical results are presented for electron temperatures in the range 1-10 eV, and a table of values is presented for use with a simple and accurate expression for the temperature dependence of the rate. Application of the results to the equilibrium of a DC discharge plasma is discussed.

DEMONSTRATION OF RESONANCE AND BEATS IN VIBRATING STRINGS USING A LOUDSPEAKER AS AN ELECTRO-MECHANICAL TRANSDUCER.

R. L. Kernell and F. P. Clay, Jr., Physics & Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508

The study of transverse waves in strings is often performed by using either an electrically driven tuning fork or a small AC electromagnet to excite the vibrations. The number of loops, and hence the wavelength of the standing wave, is changed by varying the tension in the string. A more convenient technique is to use a signal generator to drive a loudspeaker which is coupled to the string. The generator is set at a particular frequency and the tension is adjusted to obtain the fundamental resonance. The higher resonances are then obtained by varying the frequency. We have adapted the arrangement to permit the speaker to be driven by a Variac used either in lieu of or in superposition with the generator. The zero beat method is used to determine the accuracy of the generator dials in terms of the power line frequency. The zero beat frequency is easily determined either by eye or by ear. Beats are investigated further by using the Variac to excite the fundamental while successively higher harmonics are excited by the signal generator. The student can eliminate either of the vibrations by gently clamping the string between his fingers at appropriate points. This paper will demonstrate some of the phenomena of resonance and beats which are studied with this apparatus.

UNIFORM FLOW PAST AN AXIALLY UNIFORM VISCOUS VORTEX TO MODEL FLOW PAST A TORNADO. John Kroll. Department of Mathematical and Computing Sciences, Old Dominion Univ., Norfolk, Va., 23508

It is believed that the flow past a tornado causes the formation of smaller vortices which produce the "suction spots" observed along the path of destruction. Here we develop a greatly simplified mathematical model to investigate this phenomenon. An axially uniform vortex is developed by visualizing a circular tube with uniform surface suction of fluid possessing circulation at infinity. This vortex is then perturbed by a uniform flow past it. An inner asymptotic expansion of an  $E^{1/2}$  radial boundary layer is matched to an outer expansion to obtain a solution. The results show that a stagnation point developing into a secondary vortex is formed in a free shear layer at critical flow conditions. However, it is difficult to apply our results quantitatively because of the difficulty in comparing the axially uniform vortex with a real tornado vortex.

PRIMARY ELECTRON CONFINEMENT IN A MULTIDIPOLE DEVICE AND THE PLASMA LEAKAGE VELOCITY THROUGH A LOW- $\beta$  LINE CUSP.

K. N. Leung. Dept. of Physics, Madison College, Harrisonburg, Va. 22801

The effective mean free paths of the primary ionizing electrons in a multidipole device is measured by inserting a negatively biased electrode into the plasma. The plasma leakage velocity through a low- $\beta$  line cusp determined by a double Langmuir probe is shown to be approximately equal to the ion acoustic speed.

OPERATION OF A MULTIDIPOLE SYSTEM AS AN ION SOURCE. J. A. Rarick\*, K. Saadatmand\*, R. R. Page\*, T. C. Gillett\*, G. R. Taylor, and K. N. Leung; Department of Physics, Madison College, Harrisonburg, Virginia 22801.

A 7 liter, cylindrical, multidipole plasma device (20 cm diam. by 24 cm long) is operated as an ion source by enclosing one end with a set of extraction grids. The characteristics of the ion source are investigated, including the relationship of plasma density to grid bias and discharge voltages, and the effects of the magnetic field configuration and grid position on plasma density.

THE DENSITY COEFFICIENT OF POLARIZABILITY OF ORGANIC LIQUIDS BY ULTRACENTRIFUGATION. A. J. Richard. Dept. of Pharmaceutical Chemistry, Med. Col. of Va., Richmond, Va. 23298

The analytical ultracentrifuge has been used to measure the isothermal compressibility of several organic liquids. Since schlieren optics were used in these measurements, it should be possible to calculate directly a value of  $dn/dP$ , the piezo optic coefficient for the liquids. When  $dn/dP$  obtained by schlieren optics is compared to values on the same liquids obtained interferometrically there is a consistent difference which is shown by the Lorenz-Lorentz function to be due to variation of the polarizability of the liquid as a function of pressure.

PLASMA HEATING BY MEANS OF MAGNETO-ELECTROSTATIC TRAPPING OF HIGH ENERGY IONS. K. Saadatmand\*, K. N. Leung, G. R. Taylor, and R. E. Kribel. Department of Physics, Madison College, Harrisonburg, Virginia 22801.

A double plasma system is formed by installing a magnetic grid at the center of a 40 liter multidipole device. The plasma potential in the target chamber can be made negative by injecting a large amount of low-energy, non-ionizing electrons. This negative electrostatic potential well, together with the multi-cusp fields of the permanent magnets are used to trap the high energy ion beams extracted from the driver chamber. The background ion temperature in the target region is increased when the injected ions become thermalized.



COLLISIONAL DETACHMENT OF  $\text{Cl}^-(\text{Br}^-)$  IN GAS TARGETS. B. T. Smith\*, R. L. Champion\*, and L. D. Doverspike\*, Dept. of Physics, Col. of William and Mary, Williamsburg, Va. 23185

Absolute total electron detachment cross sections, as well as relative elastic and inelastic differential cross sections, have been measured for  $\text{Cl}^-$  colliding with several diatomic species and for collisions of  $\text{Br}^-$  with the rare gases. In all cases the energy threshold for detachment was found to be above the electron affinity of the negative ion. Also both elastic and inelastic differential measurements show clear onsets of the detachment channel. A qualitative explanation of the experimental results can be made using a potential curve crossing model with a complex potential formalism. An analysis and discussion of these results will be presented.

PRODUCTION OF ISOBARIC ANALOGUE STATES BY PION CHARGE-EXCHANGE SCATTERING. C. E. Stronach, Dept. of Physics, Va. State Col., Petersburg, Va. 23803; H. O. Funsten and W. J. Kossler\*, Dept. of Physics, Col. of William and Mary, Williamsburg, Va. 23185; B. J. Lieb, Dept. of Physics, George Mason Univ., Fairfax, Va. 22030; H. S. Plendl\*, Dept. of Physics, Fla. State Univ., Tallahassee, Fla. 32306; V. G. Lind\*, Dept. of Physics, Utah State Univ., Logan, Ut. 84322.

Spectra of nuclear de-excitation  $\gamma$  rays from Cr and Ni were taken with a Ge(Li) detector in prompt coincidence with incident  $\pi^+$  from the SREL synchrocyclotron. These spectra were searched for transitions in  $^{52}\text{Mn}$  and  $^{58,60}\text{Cu}$ , respectively. Transitions observed include those arising from the  $^{52}\text{Mn}$  2923-keV IAS, the  $^{52}\text{Mn}$  870-keV state, and the  $^{58}\text{Cu}$  203-keV IAS. The observed cross sections suggest that pion charge-exchange scattering preferentially excites the isobaric analogue states, and that the  $\pi^+$  act like protons in this type of nuclear reaction. (Aided by NSF grant PHY-76-15878, NASA grant NGR 47-014-006, and HEW grant GOO-75-00221.)

SEMICLASSICAL CALCULATION OF EXCITED VIBRATIONAL STATES FOR TRIATOMIC MOLECULES. R. T. Swimm\* and J. B. Delos\*, Physics Dept., William and Mary.

The vibrational spectrum for triatomic and larger molecules is believed to consist of a regular and an irregular part. The regular part consists of states for which in the classical limit the trajectories are quasiperiodic and action-angle variables can be defined, while the irregular part consists of states for which the corresponding trajectories are ergodic and action-angle variables are not meaningful. For the regular part of the spectrum we have developed a method for extending the calculations of the "Old Quantum Theory" (quantization of action) to high orders in perturbation theory. The method gives good agreement with exact quantum-mechanical calculations.

THEORY OF ELECTRON DETACHMENT IN COLLISIONS OF NEGATIVE IONS WITH ATOMS. R. D. Taylor\* and J. B. Delos\*, Dept. of Physics, Col. of William and Mary, Williamsburg, Va. 23185

The theory of electron detachment can be reduced to a curve crossing problem with a discrete potential curve crossing into a continuum of curves. Within a time dependent framework we have treated the case of a linear curve crossing into a continuum and obtained a solution consistent with the complex potential model formalism.

## Section of Biology

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

THE EFFECT OF SUBSTRATE COMPLEXITY ON MACROBENTHIC COLONIZATION. W. B. Blackburn\*, W. J. Trush\*, and A. L. Buikema, Jr. Dept. of Biology, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

Artificial substrates with a more complex surface area had higher colonization rates. Complexity was defined as the degree of physical distortion of the substrate's surface. Hemispherical concrete molds of constant area but varying complexity were implanted in a stream riffle for 1, 2, 4, and 8 week intervals. At equilibrium, complex molds had an average of 3.5 more taxa than simple molds. Invasion rates (number of immigrating organisms per day) were higher for complex molds. It is suggested that complex surfaces allow for a reduction in interspecific competition enabling a greater number of taxa to coexist on a given substrate.

HEAVY METAL CONCENTRATIONS IN MAMMALS ASSOCIATED WITH HIGHWAYS OF DIFFERENT TRAFFIC DENSITIES. Charles W. Blair\*, Anne L. Hiller,\* and Patrick F. Scanlon, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Institute and State Univ., Blacksburg, VA 24061.

Two hundred and twenty-one small mammals were trapped within 24 m of four highways and in two control areas at least 500 m from any highway. Traffic volumes on the highways involved were 525, 7,500, 24,000 and 100,000 vehicles per day in 1975. Whole body samples of the mammals were ashed and analyzed by atomic absorption spectrophotometry for levels of lead, cadmium, nickel and zinc. Levels of lead, cadmium and zinc in rodents and shrews tended to increase as traffic volume increased. A relationship between nickel levels and traffic volume was not apparent. Within areas shrews tended to have higher levels of lead, cadmium and zinc than species such as Peromyscus leucopus and Microtus pennsylvanicus. [Supported by DOT Project 60226]

ISOLATION AND PURIFICATION AND AGE-RELATED CHANGES OF O-PYROCATECHUIC ACID CARBOXYLYASE IN AGING CULTURES OF ASPERGILLUS ORNATUS. Gail D. Borgatti\* and Bradner Coursen\*, Col. of William and Mary, Williamsburg, Va. 23185.

Mycelial mats of Aspergillus ornatus grown on polycarbonate membranes placed on a defined agar medium plus 0.1% L-tryptophan showed enzyme activity to decrease with increasing age of the mats in both the crude and purified extracts of o-pyrocatechuic acid carboxylyase. To correct for depletion of minerals and glucose from the medium on which the fungus was grown, mycelial mats were placed on fresh defined medium after 110 hours of growth. In 168 and 242 hour aging cultures, the basal activity level and protein levels remained relatively unchanged while the levels to which the enzyme could be induced dropped by over 50% in activity with increasing age of the mats. In the purified extracts, the induced enzyme level of the 168 hour culture was over 5 times greater than the amount in the 242 hour culture. The protein levels of the purified enzyme increased by over 3 times the amount in the 168 hour cultures as the organism aged. Stability studies suggest the presence of altered enzymes. The purified extract of the 242 hour culture was found to be less stable than the 168 hour culture. The results of this study confirm the decreasing capacity of an organism to regulate enzyme induction with increasing age. The presence of altered enzymes, as suggested by this study, provide strong evidence that molecular modifications involved in metabolism play an important role in the progressive decline of an organism.

MORPHOLOGY AND TAXONOMY OF GALL-LIKE SCALE INSECTS, KERMES SPP. (HOMOPTERA, KERMESIDAE) IN VIRGINIA. S. W. Bullington\* and M. Kosztarab. Dept. of Entomology, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

External morphology of adult females of 3 Kermes spp., namely, K. andrei King, K. galliformis Riley, and K. pubescens Bogue is discussed and illustrated. Structural reorganization after final molt is described. During this time the heretofore flattened, ovoid, and otherwise scale-like insect is transformed into a nearly spherical shape, extensively hollowed from within, capping a huge mass of eggs, and resembling a portion of a ping-pong ball shell. Band of periventral wax pores that serve to fasten insect securely to branch is described, as are set of paired anterior and posterior lobe-like flaps which overlie and seal-off area once occupied by the true venter. These flaps now resemble a sort of "trap door" to egg-filled cavity within insect, and probably prevent pressure generated during egg-laying from dislodging the insect. Mechanisms for exit of crawlers are also discussed.

Five possible junior synonym names of K. galliformis, namely, K. nivalis King and Ckll., K. perryi King, K. pettiti Ehrhorn, K. sassceri King, and K. waldeni King, are suggested.

Keys are presented for identification of both slide and dry-preserved specimens. Information on biology, host preferences, and economic importance is given. This research has been supported by NSF Grant (DEB-76-09676).



THE EFFECTS OF A COMMERCIAL THINNING OPERATION ON THE QUALITY AND QUANTITY OF WHITE-TAILED DEER FORAGE IN MIXED-OAK FORESTS OF THE RIDGE AND VALLEY PROVINCE OF VIRGINIA. D. W. Carlile\*, J. B. Whelan\*, T. L. Sharik\*, and A. R. Tipton. Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061

The effects of a commercial thinning operation on the quality and quantity of forage available to white-tailed deer were studied during the winter of 1977. Three compartments totalling 180 acres of mixed-oak forest on the north slope of John's Creek Mt., Craig Co. Virginia were thinned over three consecutive years beginning in 1973. Samples of understory vegetation were collected from the three areas representing 1, 2, and 3 years following tree harvest and an intact control area. Oven-dried samples of three species of preferred deer forage plants from each of the three harvested areas and the control area were analyzed for percent digestibility and gross energy to obtain estimates of digestible energy in these forages. Mean estimated digestible energy values for Lowbush blueberry, Galax, and Teaberry for the control and three treated areas were 1.73, 3.29, and 3.04 respectively. Digestible energy values for the three species remained fairly constant among the control and treated areas. Productivity of preferred forage (kg/ha) decreased consistently with time since harvest over the three years considered. Mean weights of available preferred forage were 7.71 kg/ha for the control area, and 66.85, 97.51, and 193.27 kg/ha for the areas representing 3, 2, and 1 years after harvest.

USE OF A MIXED-OAK FOREST IN THE RIDGE AND VALLEY PROVINCE OF VIRGINIA BY WHITE-TAILED DEER FOLLOWING A SPRING FIRE. D. W. Carlile\*, J. B. Whelan\*, and A. R. Tipton\*. Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061

A study of the effects of a spring fire on the productivity and utilization of selected forage plants by white-tailed deer was conducted in the late summer of 1976. An intense fire burned approximately 13 acres of mixed-oak hardwood forest on the north slope of John's Creek Mt., Craig Co., Virginia on 20 April 1976. The fire caused a substantial reduction of overstory cover over the burned area and was followed by prolific growth of succulent, root suckers from a variety of woody species. Samples of five woody browse species preferred by white-tailed deer were collected from the burned and an adjacent unburned area and browsed and unbrowsed stems were counted to obtain an index of utilization. Productivity of three of the five browse species was greater on the burned area. Mean productivity on the burned area by species was 106.0, 20.1, 0, 5.6, and 5.8 kg/ha for Sassafras, Blackgum, Sourwood, Chestnut oak, and American chestnut respectively. Comparable values for the unburned area were 29.7, 13.2, 3.1, 3.0, and 9.8 kg/ha. Percent utilization by species on the burned area was 5.20, 5.56, 6.34, 0, and 0 percent for Sassafras, Blackgum, Chestnut oak, Sourwood, and American chestnut respectively. For the unburned area these values were 0, 3.01, 0, 2.38, and 4.00 kg/ha.

THE INFLUENCE OF NON-HEPARINIZED TUBE TYPE BLOOD UPON LYMPHOCYTE CULTIVATION. G. R. Cheatham\*, and E. W. Jemison. Dept. of Life Sci., Va. State Col., Petersburg, Va. 23803

Analysis of pooled lymphocyte cultures prepared from non-heparinized peripheral blood fractions show no significant deviation in chromosomal configurations. Peripheral blood fractions are collected in sodium citrate tubes in the hospital laboratory. From these fractions, lymphocyte suspensions are removed and transferred to specified culture bottles which have been divided into an experimental group of pooled blood fractions and a control group of non-pooled fractions. Incubation, arresting, and harvesting are carried out according to specifications in the Difco Chromosome Culture Procedure. Slides are prepared from the lymphocyte suspensions and stained by Giemsa preparation with a constant pH of 6.8 and temperature of 26°C. This procedure further involves comparative analysis of metaphase plates from pooled blood fractions and those of non-pooled fractions. Results show varying degrees of chromosomal contraction, but no significant alterations in morphology of the chromosomes. (Supported by NIH grant 1 S06 RR-08090-0)

INTERSEXUALITY IN GAMMARUS MINUS SAY. Anne Chester\* and Arthur L. Buikema, Jr. Dept. of Biology, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

A study was made of the reproductive system of *Gammarus minus* Say to determine if 1) intersexuality occurred; and 2) if so, did it occur externally and internally. The scanning electron microscope was used to view the external sexual characters and serial sections were made to study the internal structure of the gonads.

Genital papillae were found in 100% of the males and males never had oostegites. Mature females always had oostegites and 50% of the females had wall genital papillae. Internally, intersexuality was not observed. Males had normal testes with the vas deferens extending into the genital papillae which is located in the 7th thoracic segment. All females had normal ovaries with the oviduct ending in the 5th thoracic segment. The genital papillae found on the females had no structures associated with the gonads. Intersexuality in *Gammarus minus* was only observed externally.

INTERACTIONS OF COPPER ACETATE AND MIXED AFLATOXINS IN THE MALE SYRIAN HAMSTER, *Mesocricetus auratus*. W.L. Drake, Jr.\* and G.C. Llewellyn. Dept. of Biology, Virginia Commonwealth University, Richmond, Va. 23284

The toxicity and carcinogenicity of aflatoxins has been documented in several animals. To determine the possible role of copper treatment, the following study was undertaken: Twenty-four juvenile male Syrian Hamsters were randomly grouped into four groups of six animals each. Each group received one of the following diets: (1) ground meal; (2) ground meal + 22.9 ppm mixed aflatoxins; (3) ground meal + 0.75% copper acetate; and (4) ground meal + 22.9 ppm mixed aflatoxins + 0.75% copper acetate. The following experimental parameters were measured: food and water consumption; body weight changes; mortality; organ weights; and gross pathology. The animals receiving only the toxin showed the greatest decrease in the rate of weight gain. Group 2 also showed a greater mortality rate than did the remaining groups. The gross pathology of Group 2 was indicative of aflatoxin responses, but the remaining Groups did not show the severe pathological changes noticed in Group 2. It appears that copper may have protected against aflatoxicosis in these animals in this study.

REMOVAL OF LOW LEVELS OF POLIOVIRUS FROM WATER BY COAGULATION WITH ALUM. R. G. Graham, Jr.\*, R. C. Bates, R. C. Hoehn, and G. D. Boardman\*, Depts. of Civil Engineering and Biology, VPI & SU, Blacksburg, Virginia 24061.

Human enteric viruses are present at low levels in sources of potable water. Due to the low minimum infective dose required for such viruses, these low levels are of public health significance and will become more important as water reuse increases. The effectiveness of alum coagulation for virus removal was evaluated using a synthetic water seeded with monodispersed poliovirus LScl. Experiments were done using 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>6</sup> Plaque Forming Units (PFU) per liter. A microporous filter concentration technique was used post treatment to increase the virus titer to make possible virus enumeration by plaque assay on BGM cell cultures. Preliminary work was done to determine the efficiency of the concentration technique at 10<sup>3</sup>, 10<sup>4</sup>, 10<sup>5</sup>, and 10<sup>6</sup> PFU per liter. An average of 30.9% of the original PFU were recovered. Two coagulation test methods were used at the lower virus titers. In one, virus was added to the system after the coagulant during the flash mix period and in the other, the coagulant was added to water already seeded with virus. Removals were similar for both conditions. Alum coagulation was found to remove 95% of the virus present at the low titers. This efficiency of virus removal is similar to that observed at high initial virus titers. Therefore, it appears that alum coagulation is an effective virus removal method.



DETERMINATION OF MITOGENIC RATE AFTER SYNCHRONIZATION IN LYMPHOCYTE CULTURES. J. W. Hagwood\*, and E. W. Jemison. Dept. of Life Sci., Va. State Col., Petersburg, Va. 23803

Synchronization of lymphocyte cultures by chilling to four degrees Centigrade for one hour, was observed eighteen to twenty hours after cold shock. The lymphocyte cultures were prepared from plasma-serum fractions of peripheral blood of humans. Each plasma-serum fraction used was subcultured into three experimental and three controls. Hemacytometer counts were made at 24-hour intervals for five days. Viable counts of cells reflected lymphocyte reaction to trypan blue (.4%). Cultures exposed to cold shock showed significant increase in length growth without additional medium. (Supported by NIH grant 1 SO6 RR-08090-0)

MUTAGENIC AND/OR TERATOGENIC EFFECTS OF DIMETHYL-SULFOXIDE AND ACETYSALICYLIC ACID IN DROSOPHILA MELANOGASTER. S.D. Heinrich\*, C.S. McKenzie\*. Dept. of Biology, Va. Military Inst., Lexington, Va. 24450

When Drosophila melanogaster larvae are placed in medium containing 5% acetylsalicylic acid (ASA) by dry weight, the normal sequence of development is greatly slowed. These larvae give rise to pupae and adult flies much smaller than normal. This reduction in size appears to be directly proportional to the length of time the larvae have spent in the medium. This trait is not passed to subsequent generations and is, therefore, teratogenic. On occasion, however, a mutation did arise in the progeny of such parents.

A number of teratogenic effects are also manifested in the adult Drosophila after being exposed to dimethylsulfoxide (DMSO) as larvae. These anomalies are of four basic types and all involve the wings of the flies. All affected flies were greatly reduced in viability. The most effective teratogenic dose of DMSO was 1% by total weight. No mutagenic effects were observed.

PHYSIOLOGICAL RESPONSES OF RANGIA CUNEATA DURING HIGH SALINITY ADAPTATION. R. P. Henry\*. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

Ammonia (NH<sub>3</sub>) excretion, blood NH<sub>3</sub>, total ninhydrin positive substances (TNPS) excretion, blood TNPS, tissue intracellular free amino acids (FAA), and oxygen consumption (VO<sub>2</sub>) were measured during the period of acclimation from 2‰ to 20‰ seawater.

Blood NH<sub>3</sub> increased over the first four hours, but declined sharply thereafter while NH<sub>3</sub> excretion ceased for 4 days. TNPS excretion was insignificant, but both blood TNPS and tissue FAA increased with time. Alanine, glycine, and glutamic acid are the three major components of the FAA pool. VO<sub>2</sub> was depressed initially, but returned to normal between 16 and 21 hours.

FOOD HABITS OF GRAY FOXES AS REVEALED BY FECAL ANALYSIS. M. S. Hensley. Div. of Natural Science, Paul D. Camp Cmnty. Coll., Franklin, VA 23851.

During a 3-year study of fox/rodent interactions, 224 gray fox scats were collected and analyzed to determine seasonal and annual diet components. Standard techniques were utilized for both frequency and volume determinations.

By frequency the most important general categories on an annual basis were arthropods (64.7%) and fruits (66.0%), although the specific composition of these categories changed greatly with the seasons and no item was a staple. Furthermore, these two categories combined comprised only 26.0% of the annual volume. The only dietary staples were cottontail rabbits (Sylvilagus sp.) and woodmice (Peromyscus leucopus). Rabbit remains occurred in 23% of the scats and were the most important item by volume (30.6%). Rodents were eaten more often (38%), but made up less of the volume (12.2%). Approximately 90% of the rodent remains were woodmice. Poultry remains did not occur often, although domestic flocks were readily available. Available evidence suggests that gray foxes are opportunistic feeders whose diets vary widely in different environments.

VULNERABILITY OF BOTFLY-INFESTED WOODMICE TO PREDATION BY FOXES. M. S. Hensley. Div. of Natural Science, Paul D. Camp Cmnty. Coll., Franklin, VA 23851

On an 8-ha woodlot where live-trapping research and predator scat analysis were in progress, I attempted to determine whether woodmice (Peromyscus leucopus) were especially vulnerable to predators during periods of infestation by botfly larvae (Cyterebra fontinella). All trappable mice on the area were marked at first capture with ear tags. During months of peak bot prevalence (> 30%, August and September) fox scats were collected from known deposition sites and 32 tags were recovered, accounting for 57% of the disappearing mice. Twenty-six tags were traced to mice of known "bot history" (recovered within 20 days of final capture). These 26 individuals were used in the subsequent analysis.

Infested mice were not more vulnerable; to the contrary they were significantly less vulnerable to fox predation (p < 0.05). My previous findings were that infested mice as a class had shrunken home ranges and increased survival rates. Collectively these results suggest that botfly infestation (where mild) may very well impart a selective advantage to a host, at least where foxes or other mobile, generalist predators predominate. The infested animal, having a much reduced activity center, is considerably less likely to experience a random encounter with a fox. However, this would not hold for highly specific predators such as weasels or snakes.

AFATOXICOSIS IN Apis mellifera. Jo Ann Hilldrup, and Gerald C. Llewellyn. Dept. of Biology, Virginia Commonwealth University, Richmond, Virginia 23284

Adult worker bees, Apis mellifera, were fed diets contaminated with aflatoxin B<sub>1</sub>, in order to determine the acute and toxic effects of the fungal metabolite. The honey bees were selected randomly from a local hive and housed in nylon mesh cages. Triplicate sets of animals were fed artificial diets containing 0, 5, 10, 20, 30 and 40 ppm pure aflatoxin B<sub>1</sub>. As the level of toxin in the diet increased, the mortality rates rose. Over 90% of the bees that fed on 30 and 40 ppm diets had succumbed by the second day. A 50% level of mortality for bees feeding on 5 ppm aflatoxin B<sub>1</sub> occurred after three and one-half days.

The experimental bees were analyzed qualitatively and quantitatively for the presence of aflatoxin B<sub>1</sub> by using thin layer chromatography and visual determinations under long wavelength ultraviolet light. The lack of uniformity in the amount of food consumed as related to the body burden was probably due either to the extraction method or the formation of a metabolite in certain bees.

Honey bees were found to be more sensitive to aflatoxin B<sub>1</sub> than American cockroaches, but less sensitive than Drosophila melanogaster.



HEAVY METAL CONCENTRATIONS IN SOILS AND VEGETATION ASSOCIATED WITH HIGHWAYS OF DIFFERENT TRAFFIC DENSITIES. Anne L. Hiller\*, Charles W. Blair\*, and Patrick F. Scanlon Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Institute and State University, Blacksburg, VA 24061.

Vegetation and soil were collected at varying distances from four Virginia highways and from two control areas. Daily traffic density on the highways ranged from 100,000 vehicles per day (I 95 near Washington, D.C.) to 600 vehicles per day (VA 42 near Newport). Vegetation and soil were analyzed for lead, cadmium, nickel and zinc, using Atomic Absorption spectrophotometry. Sampling was conducted in summer and again in the fall from all areas. Preliminary results indicated that the cadmium and nickel concentrations in soil and vegetation are not strongly related with traffic density. Levels of lead and zinc in soil showed a significant decrease as distance from the highway increased and as traffic density decreased. Lead concentrations in the vegetation decreased significantly as traffic density decreased, and showed a general downward trend as distance from the highway increased. Levels of zinc in vegetation exhibited an overall, but not significant decrease as traffic density decreased. The fall vegetation samples had significantly higher lead concentrations than those collected in the summer. There was also considerable variation among vegetation species in concentrations of heavy metals. [Supported by U. S. DOT Project No. 60226]

LYMPHOCYTE STUDIES FROM POOLED PERIPHERAL BLOOD. E. W. Jemison, E. Adkins\*, and G. Cheatham\*. Dept. of Life Sci., Va. State Col., Petersburg, Va. 23803

Changes in chromosome configuration after cyclamate exposure vary with the type of tube in which the peripheral blood is collected. Giemsa stained banding patterns increase with alkalinity in heparinized tube collections. Variation in length and intensity among cells of the same cultures were significant in cultures from non-heparinized tubes. Increased staining time from 20-30 minutes in 5 ml. of Giemsa per 100 ml. of staining solution was employed throughout for consistent recording of data. Preliminary results indicate decrease in number of viable cells in pooled peripheral blood even in culture used within 24 hrs. (Supported by Minority Biomedical Support Program, NIH grant, 1 SC6 RR-08090-0)

EXPERIMENTAL ANGIOSTRONGYLUS CANTONENSIS INFECTION IN MICE. D. T. John. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, VA 23298.

*Angiostrongylus cantonensis* is a metastrongylid nematode which causes eosinophilic meningoencephalitis in man. Mice are ideally suited to the study of experimental eosinophilic meningoencephalitis; in them, as in man, *A. cantonensis* is confined to the central nervous system. This report describes the course of a primary infection of mice with *A. cantonensis*. Eighty-eight female Swiss mice aged 12-14 weeks were distributed into 2 groups; 50 mice were each infected perorally with 75 third-stage larvae and 38 mice served as controls. The course of *A. cantonensis* infection in mice can be separated into three phases: 1) incubation phase, 0-9 days, 2) acute phase, 10-35 days, and 3) chronic phase, 36-180 days. During the incubation phase mice gained weight and total and differential leukocyte counts were normal. The acute phase was characterized by weight loss, leukocytosis, reversal of lymphocyte/neutrophil ratio, mortality and various neurologic symptoms. The acute phase was marked by a severe inflammatory reaction consisting chiefly of eosinophilic polymorphonuclear leukocytes. During the chronic phase mice regained weight and leukocyte counts approached normal. Granulomas occurred wherever worms died.

MORTALITY AND MOVEMENT OF MAMMALS AND BIRDS ON A MICHIGAN INTERSTATE HIGHWAY. R. L. Kasulka, Dept. of Fisheries & Wildlife, Michigan State University, East Lansing, Mich. 48823

Three hundred and two medium-to large-sized mammals and birds from 19 species were collected from August 1, 1975 to March 15, 1976, during a daily reconnaissance of 15.5 miles of southern Michigan interstate highway. Cottontail rabbit, raccoon, opossum, muskrat, and ring-necked pheasant composed 90% of this total. Significant differences were detected in the number of animals killed per mile in relation to roadside vegetation, median vegetation, and median width. More individuals were killed per mile of highway with an unmowed, herbaceous median greater than 100 ft. wide (29.4) than were killed on highway with a mowed median less than 100 ft. wide (20.8). Mortality was also concentrated on highway sections having adjacent roadside of aspen or mixed beech-maple woods. The highest mortality, 76.6 individuals per mile, occurred where the highway median and at least one roadside was wooded. Wooded median was not extensively used by wildlife for feeding or permanent cover. However, these results indicate that wooded medians may provide attractive travel corridors which concentrate animal movement across the highway to localized areas.

A CONCEPTUAL MODEL OF THE BIOENERGETICS OF PINE VOLE POPULATIONS IN VIRGINIA ORCHARDS. S. K. Kukila\*, R. L. Kirkpatrick, and A. R. Tipton\*. Dept. of Fisheries and Wildlife Sci., V.P.I.&S.U., Blacksburg, Virginia 24061.

Recent work in abandoned and maintained orchards indicates a substantial difference in pine vole (*Microtus pinetorum*) energetics and population processes within these two orchard types. Mortality is greater and reproductive success is notably less in abandoned orchards. Determination of digestible energy, analysis of epidermal fragments, and weight of the stomach contents reveals a lower nutritional quantity and quality. A predominance of woody vegetation on the abandoned orchard floor reduces preferred food and cover and increases pine vole activity. Higher probabilities of capture and evidence of runways throughout the orchard lends support to this concept. These results suggest that pine voles must expend more energy in search for food and are receiving less energy from their food in abandoned orchards. This serves as a plausible explanation for the lower natality. Additional research will include developing a preliminary bioenergetics model which utilizes this data. Field work to determine population densities, extent of movement, and dispersal will be conducted to provide additional input and model validation.

AN INVESTIGATION OF PLASMA PROTEIN ALTERATION IN RESPONSE TO CHLORINE EXPOSURE OF RAINBOW TROUT (*SALMO GAIRDNERI*). Anne V. Lauver\* and Cletus M. Sellers, Jr. Dept. of Biology, James Madison Univ., Harrisonburg, Va. 22801

Blood samples collected from rainbow trout by catheterization were analyzed with disc gel electrophoresis. Densitometric profiles of the gels showed a characteristic number of plasma proteins in all fish. Within 2-8 hours after the onset of exposure to 0.073-0.22 mg l<sup>-1</sup> chlorine, additional plasma proteins appeared in the test animals; however, no additional proteins were evident in the plasma of control fish. At lower chlorine concentrations, the increase in time at which additional plasma proteins appeared indicated possible cumulative effects of the toxicant. Statistical analysis confirmed the significance of interactions observed between exposure time and toxicant concentration.

A SURVEY OF THE SALAMANDERS OF BUFFALO MT., FLOYD CO., VA. Frederick A. Marsteller, Jr.\* and Arthur L. Buikema, Jr. Dept. of Biology, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

The salamander community of Buffalo Mt., Floyd Co., Va. (Floyd quadrangle, U. S. Geological Survey 15' series) was surveyed between February, 1976 and April, 1977. 12 Species were collected during that period: *Notophthalmus viridescens*, *Desmognathus fuscus*, *D. monticola*, *D. ochrophaeus*, *D. quadramaculatus*, *Plethodon c. cinereus*, *P. glutinosus*, *P. wehrlei*, *Pseudotriton r. ruber*, *Gyrinophilus p. porphoriticus*, *Eurycea bislineata wilderae* and *Hemidactylium scutatum*. Distributional records indicate that six other species may be present: *Ambystoma maculatum*, *A. opacum*, *A. jeffersonianum*, *Leurognathus marmoratus*, and *Pseudotriton montanus* are possible, but *Plethodon yonahlossee* has been ruled out because of extensive efforts to find it under optimal conditions in its favored habitat.

*Desmognathus ochrophaeus* is limited to a narrow portion of permanently dry stream bed of approximately 1500 m<sup>2</sup> at an elevation of 1100 m.

EFFECTS OF REDUCED TEMPERATURE ON OXYGEN TRANSPORT IN THE BLUE CRAB, *CALLINECTES SAPIDUS*. N.A. MAURO\*, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185. (sponsored by C.P. Mangum)

*C. sapidus* has a seasonal fluctuation in its habitat temperature which is reflected in its strategy for oxygen transport. The  $\dot{V}O_2$  showed a  $Q_{10}$  of 2.0 from 25-15°C, as compared to a  $Q_{10}$  of 4.6 from 15-10°C to the "hibernation" temperature of 5°C. Pre and postbranchial blood samples were taken from animals and analyzed for  $PO_2$  and pH. Although there is no difference in pH between pre and postbranchial blood samples, pH increased by about 0.021 pH units per °C with decreased temperature. Apart from the direct increase in oxygen affinity caused by decreased temperature, the increase in pH alone, theoretically, would result in a change in  $P_{50}$  from 12 to below 5 torr based on  $\phi = -1.3$  (Bonaventura C. et al., 1974). At all temperatures the Postbranchial  $PO_2$  were high enough for the pigment to be 100% saturated with oxygen. The prebranchial  $PO_2$ s did not change from 25-15°C, and ranged from 12-14 torr. However, at 5°C, the  $PO_2$  had a significant drop to about 5 torr. This drop facilitates the release of oxygen at the tissues by a pigment with an increased oxygen affinity. If the  $PO_2$  at the tissues remained high, the pigment would be unable to release most of its oxygen, and unable to perform its transport function. The drop in  $\dot{V}O_2$ , thus, induces a drop in the prebranchial  $PO_2$ , without which little oxygen transport at 5°C could take place.

VOCALIZATIONS BY THE LIZARD, *ANOLIS GRAHAMI* (IGUANIDAE). Thomas H. Milton, Dept. of Biology, Richard Bland Col., Petersburg, Va. 23803

*Anolis grahami*, a small semi-arboreal lizard of Jamaica, produces several types of sounds in different situations. The presentation includes recordings, sound spectrograms, a discussion of possible adaptive advantages, and a review of vocalizing lizard species.

GENE FREQUENCY CHANGES IN *CEPAEA MEMORALIS*: A FIFTY-YEAR RECORD. James Murray and Bryan Clarke\*. Dept. of Biology, Univ. of Va., Charlottesville, 22903 and Genetics Research Unit., Univ. Hospital, Nottingham NG7 2UH, England.

Changes in the frequency of the genes for brown shell color ( $CB$ ) and midbanded ( $U_3$ ) have been recorded in the land snail *Cepaea nemoralis* on the coastal dunes at Berrow, Somerset, England for the period 1926 through 1975. Samples collected by Boycott and Diver were compared with extensive collections from the same localities taken in 1959-1960 and in 1975. Clinal patterns in the distribution of gene frequencies have remained the same over the intervening periods. However, there has been an overall decrease in the frequency of  $CB$  and an overall increase in  $U_3$ . These observations have been investigated by means of the G statistic and the analysis of covariance. The changes represent the results of natural selection operating at a rate of 3.5% and 4% respectively, per generation.

MODIFICATION OF RODENT MALARIA BY PRETREATMENT WITH ENDOTOXIN AND LIPID A. B. G. Newland\* and D. T. John. Dept. Microbiol., Va. Commonwealth Univ., Richmond, VA 23298

*Plasmodium berghei* is a sporozoan parasite which causes malaria in a variety of rodents. Bacterial endotoxin, a complex lipopolysaccharide of the cell wall of gram-negative bacteria, can enhance host resistance to certain infections. In this study we have evaluated the effect in mice of pretreatment with endotoxin and lipid A, the active component of endotoxin, upon subsequent infection with *P. berghei*. Male DUB/ICR mice weighing 20-25 g were administered i.p. a single dose of endotoxin (*Escherichia coli* 0127:B8, 5 mg/kg) or lipid A (50 mg/kg). Twenty-four hours later all mice, including nontreated controls, were each inoculated i.p. with  $1 \times 10^7$  *P. berghei* (NYU-2 strain) infected erythrocytes. Hematological determinations included hematocrit, hemoglobin, total erythrocyte count and parasitemia. Cumulative mortality was also recorded. In all instances endotoxin-pretreated mice demonstrated increased resistance to *P. berghei* infection as compared to nontreated controls. Mean survival time was significantly greater for endotoxin-treated mice than for nontreated controls. Lipid A, however, appeared to have little effect upon the course of malaria infection.

THE USE OF CHRISTMAS BIRD COUNTS IN MONITORING PRESENCE OF FREE-RANGING EXOTIC BIRD SPECIES. Timothy G. O'Brien\* and Patrick F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

By utilizing Christmas bird counts (CBC), it may be possible to set up and maintain a monitoring system for distribution of exotic bird species throughout the United States. The 1975 CBC was divided into 10 blocks, each of 100 observation units, encompassing the continental United States and Alaska. A random sample of 10 observation units was drawn from each block, assuring an even distribution over the continental United States plus Alaska. Ten major ports of entry were also studied. Each unit in the sample was examined for each of the years 1956, 1966, 1973, 1974, and 1975. The occurrence of exotic species and the number of each was recorded for each sample unit. Results showed that a total of 30 exotic bird species were observed in CBC's. The greatest variety of species was found around the major cities studied especially Miami, FL, and Los Angeles, CA. The most abundant and widespread exotic species were the European starling, house sparrow, pheasant, cattle egret and house finch. The present survey did not indicate that all known exotic bird species were detected in CBC's nevertheless it could be concluded that CBC's could be a valuable means of monitoring the presence and possible abundance of exotic bird species.



DISTRIBUTION NOTES ON PLETHODON YONAHLOSSEE DUNN IN S.W. VIRGINIA. D.W. Ogle. Dept. of Biology, Virginia Highlands Community College, Abingdon, Virginia, 24210.

A range extension for Plethodon yonahlossee east of the New River drainage in Pulaski County, Va. is cited. This location is the northern most for the species and adds a new county to the Virginia records. A collection from the southern Blue Ridge escarpment in Carroll Co., Va., is described. When compared to published information on the species, these collections provide interesting data. All specimens were taken more than 30 m. from streams, the individuals collected were taken from lower elevations, and no hybrid material was detected. The collections were unusual in that more yonahlossee were captured than P. glutinosus, and though the species overlap along the escarpment there does seem to be a correlation between population density and altitude.

OBSERVATIONS ON THE DISTRIBUTION AND HABITAT REQUIREMENTS OF THE HISPID COTTON RAT, SIGMODON HISPIDUS, IN CENTRAL VIRGINIA. John F. Pagels. Department of Biology, Virginia Commonwealth Univ., Richmond, Va. 23284

The hispid cotton rat, Sigmodon hispidus, is found in a variety of grass to grass-shrub habitats in tropical America and northward into the south-central United States. Observations of range expansion northward by the cotton rat in Virginia are similar to numerous observations of range expansion in the central and western States.

I have since 1970 collected cotton rats at numerous localities extending from the upper Coastal Plain to the higher Piedmont of south-central Virginia. The northernmost site is in Powhatan County just south of the James River. Cotton rats were captured north of the James River near Varina in southeastern Henrico County. Old fields, including edges, highway rights-of-way and fence rows, in the grass-shrub stage that contain dense shrubby growth, primarily Japanese honeysuckle, Lonicera japonica, seem to be preferred habitat of the cotton rat in central Virginia.

LABORATORY INTERACTIONS OF THE HISPID COTTON RAT, SIGMODON HISPIDUS, AND THE EASTERN MEADOW VOLE, MICROTUS PENNSYLVANICUS. John F. Pagels and Martin W. Goehle\*.

Dept. of Biol., Va. Commonwealth Univ. Richmond, Va. 23284

Expansion of range northward by the hispid cotton rat, Sigmodon hispidus, has brought it into increased contact with a northern form, the eastern meadow vole, Microtus pennsylvanicus, often considered its ecological counterpart. The purpose of this study was to determine the interactions of these species in a "behavior compartment" that contained two resting areas above floor level, and at floor level a nesting area and activity wheel, with food and water ad libitum. There was no significant difference in the change in body weight of the experimental animals whether alone or paired in any combination in the chamber. The species introduced first into the chamber preferred either the wheel or the nest area and the second form introduced was more often in the areas above floor level. Wheel activity of both species increased when the other form was introduced and in all cases Sigmodon was much more active when alone than Microtus when alone. These laboratory observations in an artificially complex situation generally support field observations that the two forms are able to coexist providing that diverse habitat is present.

GLUCOSE 6-PHOSPHATE DEHYDROGENASE ISOENZYMES IN THE CRAB, COENOBITA CLYPEATUS. Suzanne Payne\* and James E. Dendinger. Dept. of Biology, Madison College, Harrisonburg, Va. 22801

As the molting process begins in crustaceans, many metabolic changes become apparent, especially in lipid and carbohydrate metabolism. Studies have indicated glycolysis to be the major pathway of glucose degradation during the pre-molt stage and the hexose monophosphate shunt to be a major pathway in the intermolt stage in some crustaceans. Metabolic changes of this type are known to be mediated by enzymes. Some of these enzymes occur as isoenzymes which catalyze the same reaction, but differ in kinetics. One of these enzymes is glucose 6-phosphate dehydrogenase, which regulates the flux through the hexose monophosphate shunt in most animals. We investigated the isoenzyme patterns of glucose 6-phosphate dehydrogenase in various tissues of the hermit crab, Coenobita clypeatus, and changes in these patterns resulting from changes in the hormonal state of the animal.

MORPHOLOGICAL CHANGES IN HUMAN LYMPHOCYTES AFTER CALCIUM CYCLAMATE EXPOSURE. B. A. Rivers\* and E. W. Jemison. Dept. of Life Sci., Va. State Col., Petersburg, Va. 23803

Peripheral blood lymphocyte response in vitro to calcium cyclamate vary with the concentration of cyclamate. Plasma serum fractions under phytohemagglutinin (PHA) stimulation are cultured. Measures of mitogenic activities at T24hrs., T48hrs., T67hrs., and T72hrs. by hemacytometer counts produce data from which growth curves are plotted and analyzed. Preliminary results indicate, during the period of cyclamate exposure (T67hrs.-T72hrs.) the cyclamate seems to assure stability of the lymphocyte cultures and increases the mitogenic activity of the lymphocytes. Results confirm and show deviations from data reported by Boone, Knight and Jemison (1973-1975). Specific deviations at .02 molar concentration of calcium cyclamate include such aberrations as chromosome balls, rounded chromosome ends, ring formation, non-separation of chromatids, symmetrical exchange and condensed chromosomes. (Supported by Minority Biomedical Support Program, NIH grant, 1 S06 RR-08090-0)

A COMPARISON OF THE MACROINVERTEBRATE INFAUNA OF TWO NON-TIDAL ESTUARINE SANDY SUBSTRATE COMMUNITIES†. W. Wright Robinson\*, and James F. Matta, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508.

The structure of two non-tidal sandy bottom communities was studied using seasonal sampling between October 1975 and July 1976 in the Back Bay National Wildlife Refuge, Virginia and at a location 1 mile north of Duck, North Carolina.

The North Carolina location was sampled along three transects perpendicular to the beach. A small man-made marsh, located at the base of one transect, played an increasingly important role in the area. Tabanids, Chironomids, dytiscids and increased densities of oligochaetes (Pelosclex sp.) characterized the developing marsh. The amphipod Lepidactylus dytiscus dominated the nearshore non-marsh area; the polychaetes Scolecoplex viridis and Lysippides grayi and the brackish water clam Rangia cuneata dominated the deeper waters.

One transect was sampled at the Back Bay location. Salinities on this transect averaged lower than those at Duck and while most species collected at Duck were present, the most abundant organisms on this transect were chironomids and oligochaetes with Gammarus fasciatus dominating during the summer months.

\*This work supported, in part, by the U.S. Army Coastal Engineering Research Center under contract DACW72-75-R-0019.



A SEARCH FOR L-TRYPTOPHAN-2,3-DIOXYGENASE IN *ASPERGILLUS ORNATUS* RAPER. A. A. Ruiz, and Bradner W. Coursen\*. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

Mycelial mats and liquid-grown cultures of *Aspergillus ornatus* exposed to L-tryptophan were examined for evidence of L-tryptophan-2,3-dioxygenase activity both spectrophotometrically and chromatographically. Mats of two different ages were examined to determine if: 1. the enzyme was present and 2. if the emergence of enzymatic activity was age-related. The cellular extracts failed to show any significant enzymatic activity throughout both detection methods.

The discovery of L-kynurenine in the growth medium but not in the cells indicated a very small amount of L-tryptophan is catabolized in *A. ornatus* and several possible explanations of this phenomenon are discussed.

GROWTH RATES OF CAPTIVE WHITE-TAILED DEER FAWNS. M. Douglas Russell\*, Robert W. Vogelsang and Patrick F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ. Blacksburg, VA 24061.

Data on body weight and heart girth measurements were collected from fifty-two white-tailed deer (*Odocoileus virginianus*) fawns (1-50 days old) during the intervals 2 June to 23 July, 1975 (423 observations from 20 fawns), and 7 June to 20 July, 1976 (708 observations from 32 fawns). The fawns were born to captive does at the deepen facilities at VPI&SU and were raised by their dams. Thirty-nine fawns were born as twins and 13 were born as singles. Data were analyzed by analysis of variance. Age, weight, and heart girth relationships were all highly correlated. The correlation coefficients ( $r$ ) for age-weight was  $r = 0.95$ , for age - heart girth was  $r = 0.87$ , and for weight - heart girth was  $r = 0.94$ . Three growth stages were apparent for young fawns. Using an inverse regression procedure with age as the dependent variable, the following three models were developed for each of three growth stages: Age (<15 days) =  $-10.6036 + 1.6624 [\text{Weight}(\text{lbs})]$ ,  $R^2 = 0.995$ ; Age (16-30 days) =  $-40.7200 + 3.6401 [\text{Weight}(\text{lbs})]$ ,  $R^2 = 0.94$ ; Age (31-50 days) =  $8.1804 + 1.4218 [\text{Weight}(\text{lbs})]$ ,  $R^2 = 0.32$ . Using true regression with weight the dependent variable, the following model was developed:  $\text{Weight}(\text{lbs}) = 45.6349 + 4.0666 [\text{heart girth}(\text{ins})]$ ,  $R^2 = 0.89$ . [Supported by McIntire-Stennis project 636201].

THE EFFECTS OF A SYNTHETIC JUVENILE HORMONE ON THE DIPTERAN PUPAL PARASITE *NASONIA VITRIPENNIS* (HYMENOPTERA: PTEROMALIDAE). H. C. Sagan\* and N. J. Fashing. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185.

Insect juvenile hormones and their analogues (JHA's) have received considerable attention in recent years because of their potential as insecticides. Considerably few studies, however, have investigated their effect on non-target organisms such as parasitic wasps. The present study evaluated the effects of Zoecon Corporation's JHA, Altosid SR-10 (isopropyl (E,E)-11-methoxy-3,7,11-trimethyl-2,4-dodecadienoate) on the pupal parasite *Nasonia vitripennis* when the compound was administered via its dipteran host *Sarcophaga bullata* (Diptera: Sarcophagadae).

Fly larvae, <24 hr. old, were reared to pupae on a diet of ground beef liver containing JHA at a concentration of 100% by weight, a concentration much higher than necessary to prevent metamorphosis in the fly. For controls, distilled water was substituted for JHA. Newly formed pupae were exposed to wasps <48 hr. old and maintained at 27°C; 60-70% RH. A t-test demonstrated that the numbers of adult wasps per pupa emerging from JHA treated pupae did not differ significantly ( $.9p > .5$ ) from the numbers emerging from controls. Therefore, Altosid SR-10 has no effect on the parasite when administered via its host. Preliminary tests, however, in which high levels of Altosid SR-10 were applied directly on wasp pupae show definite effects on the degree of maturity achieved by the wasps.

A PRELIMINARY ASSESSMENT OF THE ECOLOGICAL IMPACT OF THE VIRGINIA FIBRE CORPORATION EFFLUENT UPON THE BENTHIC MACRO-INVERTEBRATE COMMUNITY OF THE JAMES RIVER. Virginia T. Shepherd and Richard S. Herd, Environmental Studies Program Sweet Briar Col., Sweet Briar, VA. 24595

This is a preliminary assessment of the structure of the benthic macroinvertebrate community of the James River following one year of discharge by Virginia Fibre Corporation, a corrugated paperboard manufacturer. Post-discharge data is compared to both an upstream control station and to data gathered during the 18 month pre-discharge baseline study. We collected 173 taxa pre-discharge as opposed to 124 taxa collected post-discharge. The principal orders of macroinvertebrate maintained their relative order of abundance within the study area, however there was a decline in number of genera within orders. A shift in dominance occurred among stations downstream of the discharge. Analysis of variance did not show a significant difference in community diversity between pre- and post-discharge data or between stations. The pollution sensitive orders of macroinvertebrates were found in much the same proportions as in pre-discharge collections. *Corbicula* invaded the study area in 1974 and now composes a significant proportion of the community.

TRENDS IN THE BURROWING ACTIVITY OF THE FLORIDA WATER RAT IN A FIELD OF SUGAR CANE. David E. Steffen\* and Patrick F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Institute and State University, Blacksburg, VA 24061.

In its natural habitat the Florida water rat, *Neofiber alleni*, is a marsh dweller, but in sugar cane fields they are primarily fossorial, piling mounds of muck outside burrow openings. The burrowing activity in six burrow systems of the Florida water rat was monitored in March 1976, monthly from June through December 1976, and again in March 1977 in one sugar cane field in South Florida. The total number of burrows was greatest in June and steadily decreased in the months following. The lowest numbers were observed in March, 1976, and in March, 1977. A relatively constant number of burrows associated with large mounds of muck was found possibly indicating a constant maintenance activity within burrow systems. New burrowing activity was highest in June and July with peaks also occurring in September and March. In March 1976, significantly ( $P < 0.05$ ) more burrows were found under the rows of cane trash left in the field after harvest than were found in the more open areas. The trends in burrowing activity were discussed as they related to agricultural practices, temperature, rainfall and live trapping success.

[Supported by the U.S. Fish and Wildlife Service and the Florida Sugar Cane League]

TOXIC AND TERATOGENIC EFFECTS OF AFLATOXIN B<sub>1</sub> IN JAPANESE MEDAKA EGGS (*Oryzias latipes*). G.A. Stephenson\*, G.C. Llewellyn, and J.W. Hoffman\*. Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284.

Eggs, Embryos, and fry of the Japanese Medaka, subjected to different concentrations of aflatoxin B<sub>1</sub> (AFB<sub>1</sub>), revealed certain toxic and teratogenic responses. The test results were compared to other studies of the toxin to evaluate its potential for biological assay. The AFB<sub>1</sub> concentrations varied from 0.05 ug/ml to 15.10 ug/ml.

The developing medaka showed an increased lethality level with an increase in the AFB<sub>1</sub> concentration. The LC<sub>50</sub> for the eggs studied was 0.18 ug/ml AFB<sub>1</sub> over the 720-hour test period. No lethality was recorded for eggs placed in control solutions.

Teratogenic responses appeared to be more numerous in the medaka than in other reported test species. Teratogenesis was noted for the circulatory system, optical development, appendage development, swim bladder, and spleen. Controls showed no evidence of a teratogenic activity.

This test combines advantages of descriptive pathology, lethality, and teratology for confirmation of AFB<sub>1</sub> activity.



DIPHENYL MERCURY EFFECTS ON CELL DIVISION, CALCIFICATION AND NET PHOTOSYNTHESIS IN THE COCCOLITHOPHORID ALGA, *CRICOSPHAERA CARTERAE*. E. F. Stillwell, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508, and J. P. Bryant\*, Eastern Va. Med. Sch., Norfolk, Va. 23508.

Diphenyl mercury (DPM) was found to produce effects on cell division, calcification, and net photosynthesis in the coccolithophorid alga, *Cricosphaera carterae*. Compared with controls the rate of cell division was progressively more inhibited in 20 ppb and 55 ppb DPM, and division was completely blocked at 110 ppb DPM. The inhibitory effects were somewhat more pronounced in cells which had been decalcified prior to adding the diphenyl mercury. Calcification in decalcified cells was retarded in 20 ppb and 55 ppb DPM and completely inhibited in 110 ppb DPM. Inhibition of division and calcification was reversible after 6 days in DPM. The net photosynthetic rate was inhibited almost linearly with increasing concentrations of DPM tested.

EFFECTS OF ACUTE INTRAFOLLICULAR PRESSURE INCREASE ON COITUS-INDUCED RABBIT GRAAFIAN FOLLICLES. R. James Swanson, Dept. of Biological Sciences, Old Dominion U., Norfolk, Va. 23508

The volume of postcoital rabbit follicles was acutely increased with isotonic normal rabbit serum (NRS) in five volume increments, injected intrafollicularly to determine the effects on ovulation. Volumes of 0.2 and 0.5  $\mu$ l NRS injected into 2-hour postcoitus Graafian follicles had no apparent effect on the ovulation competency of the follicle (80% ovulation). Volumes of 0.7, 1.0, and 1.5  $\mu$ l NRS injected into 2-hour postcoitus Graafian follicles blocked ovulation in 74% of injected follicles ( $p < 0.01$ ). Acute isotonic volume increase in the postcoital follicle, rather than hastening ovulation, inhibits ovulation in direct proportion to the volume injected. The basis for the blockade may be a reversal of pressure relationships between the vascular system and the intrafollicular space.

DETERMINING OPTIMUM CONTROL STRATEGIES FOR THE EUROPEAN WILD BOAR (*Sus scrofa*) IN THE GREAT SMOKY MOUNTAIN PARK USING COMPUTER SIMULATIONS. Alan R. Tipton, Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ. Blacksburg, VA 24061

Three different forms of the Leslie matrix model are presented. The analytical structure and biological assumptions for these models are discussed. The basic models were modified to include seasonal variation in life history parameters, sex specific mortality and grouping of older age classes. Data from the literature was utilized to determine optimal harvest and control strategies. Results from simulations using the modified form of the basic Leslie model indicate optimal harvest strategies should concentrate on the older age classes, optimal control on a combination of younger and older age classes. Given economic and biological constraints the hog population could be effectively reduced by cropping 40% of the older group of animals and 60% of the juvenile age class using a continuous control program. For optimal harvest all of the older animals can be taken and 45% of the 2-2½ year animals. Results from the other two forms of the model are quite different. The implications of these differences are discussed.

CYCLIC AMP AND ENZYME INDUCTION IN AGING CULTURES OF *ASPERGILLUS ORNATUS* RAPER. D. F. Unger\*, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

The presence of endogenous cyclic AMP was demonstrated in mycelial mats of *A. ornatus*. Purification increased the cyclic AMP concentration in excess of eight times the level observed in crude extracts. The endogenous concentration of cyclic AMP was reduced by the addition of phosphodiesterase. In aging mycelial mats the concentration of cyclic AMP declined 60%.

The inducible enzyme 2, 3 dihydroxybenzoic acid carboxylase was detected in crude extracts. The addition of 0.1% L-tryptophan to the medium increased the enzyme activity to five times the observed level in uninduced mats. With increasing age, the level to which the enzyme could be induced, decreased.

A relationship between the age-related decline in cyclic AMP and 2, 3 dihydroxybenzoic acid carboxylase may exist. However, addition of  $10^{-3}$  M cyclic AMP to the medium neither increased the inducible enzyme activity nor cyclic AMP concentration. The addition of L-tryptophan to the medium did not alter the endogenous cyclic AMP concentration in early stationary phase. A discussion of the role of these effects is included.

PROGESTIN LEVELS AS INDICATORS OF MULTIPLE PREGNANCY IN WHITE-TAILED DEER. R. W. Vogelsang\*, R. L. Kirkpatrick, and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Progestin levels were determined throughout pregnancy in twenty captive yearling white-tailed deer (*Odocoileus virginianus*). Each animal was bled 8 times, at approximately 4 week intervals, and progestins (ng/ml) were determined by competitive protein binding (CPB) assay. Progestin levels were analyzed with respect to the number of fawns in utero and significant ( $P < 0.05$ ) differences were observed between does carrying 0, 1 and 2 fawns. Progestin levels (mean  $\pm$  S.E.) were consistently lower in does carrying no fawns ( $0.3 \pm 0.1$ ) and seldom ranged above 1 ng/ml. Following the first month of pregnancy there was very little overlap in progestin levels between does carrying single or twin fawns. The progestin level in does carrying one fawn ( $2.3 \pm 0.2$ ) was significantly ( $P < 0.05$ ) higher than the level in non-pregnant does, but significantly ( $P < 0.05$ ) lower than the level in does with twin fawns ( $4.6 \pm 0.4$ ). In almost all instances, a progestin level less than 4.0 ng/ml indicated a doe was carrying only a single fawn, while a level above 4.0 ng/ml indicated a doe was carrying twins. [Supported by McIntire-Stennis project No. 636201-0.]

INFLUENCE OF TIME OF SAMPLING AFTER SHOOTING ON BLOOD CHARACTERISTICS OF WHITE-TAILED DEER. James A. Wesson, III\*, Patrick F. Scanlon, Roy L. Kirkpatrick and Henry S. Mosby. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ. Blacksburg, VA 24061.

Fifteen captive white-tailed deer (*Odocoileus virginianus*) were shot and blood was collected at collapse, at 5 minutes, and at 30 minutes after collapse to measure the influence of time of collection upon blood measurements. The deer consisted of 4 males and 11 females. Blood measurements were: Packed cell volume (PCV) blood protein, blood glucose, blood urea nitrogen (BUN), corticoids, progestins, and androgens. PCV and blood glucose values of individual deer changed erratically during the 3 time periods. BUN, total proteins, corticoids, progestins and androgens measurements did not vary significantly due to the time of blood sampling after death though there were substantial individual variations in corticoid values. Blood collections from shot animals should follow rigorous standardization as to time of death and blood vessel sampled. Further it appears undesirable to combine or compare samples collected at different times after death. [Supported by McIntire-Stennis project #636201-0].

INFLUENCE OF IMMOBILIZING DRUGS ON BLOOD CHARACTERISTICS OF COTTONTAIL RABBITS. James A. Wesson, III\*, Patrick F. Scanlon, Roy L. Kirkpatrick and Henry S. Mosby, Dept. Fisheries and Wildlife Science, Va. Polytechnic Inst. and State Univ. Blacksburg, VA 24061.

Eighty-four adult cottontail rabbits (*Sylvilagus floridanus*) were used in experiments to determine effects of immobilizing drugs on blood characteristics. Rabbits were assigned to one of 6 treatments (14 to each). The treatments were succinylcholine chloride (SCC), RO-5-3448, a combination of phencyclidine hydrochloride plus promazine hydrochloride (PH+P) and a control group for each drug. SCC was given i/m, and rabbits bled by heart-puncture at injection and either 30 or 60 mins. after injection. RO-5-3448 was given orally (P/O) and bleeding was done at administration and again at 30 or 60 minutes after dosing. PH + P was given i/m with bleeding at the same time as the RO-5-3448 group. PCV values decreased (NS) in all treatment and all but one control groups. Plasma proteins were significantly ( $P < 0.05$ ) reduced in PH + P treated rabbits bled at 60 mins. post-injection. Blood glucose increased significantly ( $P < 0.05$ ) in SCC treated rabbits at 30 mins. post-injection and in 1 group of control rabbits at 60 mins. post-injection. Corticoids increased significantly ( $P < 0.05$ ) in SCC and controls at 30 mins post-injection.

[Supported by McIntire Stennis Project #636201]

TRYPTOPHAN TRANSPORT AND ENZYME INDUCTION IN AGING CULTURES OF *ASPERGILLUS ORNATUS*. P.H. Wilson\* and B.W. Coursen\*. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

Mycelial mats of the filamentous fungus, *Aspergillus ornatu*s were tested at various ages for induction by tryptophan of o-pyrocatechuic acid carboxylase, an enzyme of the tryptophan catabolic pathway. Also tested at 7 and 10 days of age were the transport rates of total tryptophan into the system, rates of tryptophan entry into a TCA soluble pool and rates of tryptophan incorporation into protein.

Enzyme induction decreases significantly with age but the specific activity of a 10 day mat can be brought to the level of a 7 day mat by 1) lengthening the induction period or 2) increasing the concentration of the inducer/substrate. These data indicate the internal level of tryptophan available for catabolism, (i.e. that in the TCA soluble pool) is critical to the induction process and may account for the age-related difference in enzyme activity.

DISCRIMINATION OF SIMPLE PATTERNS BY THE HONEYBEE. Mary A. Linehan Wiseman\* and Norman J. Fashing, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185.

Experiments on visual acuity in the honeybee performed by Hertz (circa 1930-34) led to the conclusion that honeybees cannot distinguish between simple patterns of approximately equal complexity such as triangles, squares, circles and rectangles. She found they could, however, readily distinguish from any of these a figure which was slightly more complex such as a cross, a "Y", a hollowed-out square or four closely spaced bars. She also found they could not distinguish between any of these more complex figures.

The present study reinvestigated the conclusions of Hertz by using similar test patterns but a different experimental design. Hertz trained bees to horizontally placed test patterns at feeding stations, whereas the present study employed an apparatus in which the bees were trained to a pattern centrally placed in a vertical position over the hive entrance. The bees were thus forced to fly through a hole in the center of the pattern to go in and out of the hive. Advantages of the latter method are the added dimensions of up and down and left and right, as well as greater motivation of the bees to learn a pattern (the urge to enter the hive being greater than that to feed at a particular station). Bees were trained to a particular pattern (standard), and then a series of preference tests were conducted between that standard and all other patterns. Results demonstrate conclusively that bees can distinguish between simple patterns.

TAXONOMIC IMPLICATIONS OF SPERMATOOA AND THEIR ASSOCIATIONS. J.W.E. Wortham, Jr.\*, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508, P.I. Brown\*, Dept of Anatomy, Sch. of Med., Marshall Univ., Huntington, W.Va. 25701 and J. Martan\*, Dept. of Zoology, Southern Illinois Univ., Carbondale, Ill. 62901.

Spermatozoa of 15 species of ambystomatid salamanders, 28 species of plethodontid salamanders and 7 mammalian genera belonging to the family Sciuiridae were studied with the light microscope. In the ambystomatid salamanders, a tail membrane was observed on the spermatozoa of 12 species of *Ambystoma* and 2 species of *Rhyacosiredon* but was absent in *Rhyacotriton*.

Twenty-eight species of the family Plethodontidae, including 11 genera representing both subfamilies and all tribes in the Plethodontinae exhibited a characteristic cytoplasmic droplet attached to the middle piece of the sperm.

The epididymal spermatozoa of the 8 genera (*Glaucomys*, *Sciurus*, *Citellus*, *Tamias*, *Ammospermophilus*, *Tamiasciurus*, *Cynomys* and *Eutamias*) of the mammalian family scuiridae formed unusual associations called polarized cylindrical bodies.

It is apparent that various spermatozoan characteristics such as the typical cytoplasmic droplet and polarized cylindrical bodies can be assigned to higher taxa while other characteristics, such as the tail membrane may reflect a lower taxon. We therefore suggest that more attention be paid to spermatozoan morphology as a taxonomic character in studying vertebrate relationships.

THE EFFECTS OF VITAMIN (A,K, THIAMINE) AND MINERAL (Ca, Na) DEFICIENCIES IN HOST ALBINO RATS ON THE ATTACHMENT AND DEVELOPMENT OF THE GULF COAST TICK, *AMBLYOMMA MACULATUM* KOCH. D.M. WANCHINGA\*. Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508.

Effects of vitamins (A,K, Thiamine), and Ca and Na deficiencies in host rats as affecting attachment and development of the tick, *Amblyomma maculatum* were examined. Each Group of three rats was fed a diet deficient in a specific vitamin or mineral salt. Adult ticks were fed on rats at 25 days and 53 days; while larvae and nymphs were fed on rats at 86 and 96 days after the start of the feeding program.

Sodium and vitamin K deficiencies in host rats significantly hastened the life-cycle ( $P < 0.05$ ). No effects were observed on the development pattern of ticks fed on thiamine and vitamin A deficient rats.

Ticks that fed on rats maintained on Ca-deficient diet produced considerably fewer eggs, and had a significantly lower hatching, and moulting percentages ( $P < 0.001$ ).



## Section of Botany

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

THE EFFECT OF DIFFERING MEDIA AND TEMPERATURE ON GROWTH OF *CORYNESPORA CASSIICOLA*. James C. Adams\*, M. K. Roane, and L. D. Moore, Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

A study was conducted to determine a suitable medium and temperature range for more rapid growth of *Corynespora cassiicola* (Berk. & Curt.) Wei. Growth of *C. cassiicola* was observed on four liquid media (tobacco extract, tobacco extract plus sucrose, tobacco extract plus yeast extract, and tobacco extract plus sucrose and yeast extract) at 15C, 20C, 25C and 30C over a 20 day period. Differences in growth of the fungus were recorded as changes in dry weight of mycelium and pH changes in the media for each growth period and temperature.

VEGETATION CHANGES IN THE GREAT DISMAL SWAMP BETWEEN 1937 AND THE PRESENT. L. Scott Andrews, U.S. Geological Survey, Reston, Virginia 22092

Black and white historical photographs of the Great Dismal Swamp were interpreted to produce both black and white and colored vegetative cover maps at 1:24,000 scale. These products are for overlay on U.S. Geological Survey orthophoto maps.

Aerial photography from 1937, 1953, 1971, and 1975, and timber and fire records, were used for mapping. The photographs were viewed stereoscopically to yield height, texture, and canopy information. Vegetation unit boundaries were rectified to the proper scale by use of recognizable landmarks.

The 1937 photography followed extensive timbering, allowing identification of specific clear-cut and burned areas. Interpretation of 1953 photographs indicated the height and extent of regeneration in previous clear-cut areas.

Further interpretations were made using 1971 photographs. Regeneration of Atlantic white cedar has taken place in skid trails. The marsh on the swamp's western side has receded dramatically. Recent clear-cutting of Atlantic white cedar was delineated using 1975 color-infrared photographs.

CULTURAL AND PHYSIOLOGICAL CHARACTERISTICS OF TEN *Endothia gyrosa* ISOLATES FROM LANGLEY AIR FORCE BASE, VIRGINIA. D. N. Appel, R. J. Stipes and E. W. Looney. Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061 and Langley Air Force Base, VA 23365

About 110 of 500 pin oaks (*Quercus palustris*) examined at Langley Air Force Base, Virginia, exhibited typical pin oak blight symptoms caused by *Endothia gyrosa*; 42 cultures of *Endothia* have been successfully isolated from orange stromata associated with the cankered portions of selected trees. Infections occurred on exposed roots, the main bole, branches and twigs, each from which a total of 10 isolates were chosen for observation of cultural and physiological characteristics. A suspected isolate of *E. parasitica* obtained from *Castanea dentata* at Blacksburg, Va., was used comparatively in the study. Consistent differences in growth rate (colony diameter increase) on potato-dextrose and glucose-yeast extract agars were exhibited by some of the 10 isolates. These trends were altered when isolates were grown on a defined glucose-asparagine medium. Liquid culture technique was more useful than agar culture in determining vitamin deficiencies. On a glucose-asparagine liquid medium amended with different combinations of vitamins, suspected *E. gyrosa* and *E. parasitica* isolates were deficient for thiamine, biotin or pyridoxine. Methyl-2-benzimidazolecarbamate phosphate was slightly more toxic to *E. parasitica* than to *E. gyrosa*. cursory observations of isolate aversion and pigment production phenomena were made.

EFFECTS OF CANAVANINE ON ROOT DISEASE OF LEGUMES CAUSED BY *PYTHIUM* SP. J. A. Barron, III. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The effects of L-canavanine, the oxyguanidino structural analogue of arginine, on growth and pathogenic activities of *Pythium* sp. were observed. Seven of eight isolates tested were enhanced in growth by adding canavanine ( $1.8 \times 10^{-4}M$ ) to the basal fungus culture medium.

Excised roots of soybean (*Glycine max* Harosoy) and jackbean (*Canavalia ensiformis* (L.) DC., a canavanine-synthesizing plant, were treated with the amino acid, inoculated with *P. debaryanum*, and gnotobiotically cultured. The disease incubation period in both plants was unaffected by canavanine, although it was substantially shorter in jackbean under any circumstances. Treated, inoculated soybean roots exhibited growth patterns indicating that canavanine enhanced the disease process. However, this activity was not evident in jackbean. In addition, non-inoculated roots of both plants were partially inhibited in growth by canavanine treatment.

Further study of the effects of this amino acid on soil-borne plant disease could be beneficial. (Aided by a Sigma Xi grant)

THE EFFECTS OF VARIOUS WAVELENGTHS OF LIGHT ON SPORE GERMINATION AND GAMETOPHYTE MORPHOGENESIS OF *POLYPODIUM VIRGINIANUM* L. W.E. Boyd, Jr.\* and P.T. Nielsen. Dept. of Biology, James Madison University, Harrisonburg, Va. 22801

Spores of *Polypodium virginianum* L. require light to germinate. Red light is most effective while blue light actually inhibits germination compared to the dark controls. Germination appears to show red, far-red reversibility suggesting possible phytochrome involvement.

Transition from protonemal to prothallial development requires blue light. Gametophytes grown in red light remain actively growing in the protonemal stage for up to 36 days although their potassium content begins to decrease significantly after the 26th day.

Kinetin (5 mg/L) has no effect on development but does stimulate potassium uptake approximately 2 to 3 fold on a dry weight basis under both white and red light conditions. In so doing, kinetin prevents the leakage of potassium from protonemata maintained under red light.

A COMPARISON OF STEROL CONCENTRATIONS IN SUNFLOWER AT DIFFERENT STAGES OF DEVELOPMENT AFTER TREATMENT WITH TWO CONCENTRATIONS OF CYCOCCEL. S. S. Brown\*, D. M. Stuhr\*, and D. M. Orcutt. Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, Va. 24061.

Conflicting reports have indicated that Cycocel can inhibit, increase, or have no effect on sterol biosynthesis. This study was conducted to define the importance of Cycocel concentration and time of harvest on plant sterol levels.

Sunflower seedlings (*Helianthus annuus* L.) in hydroponic culture were treated with Cycocel (2-chloroethyltrimethylammonium chloride) at concentrations of 100 and 500  $\mu\text{g/ml}$ . Seedlings were harvested one, two and four weeks after treatment. No major change was detected in lipid content in terms of percent dry weight. One week after treatment, little difference was noted regarding total concentration of major free sterols (cholesterol, campesterol, stigmasterol, sitosterol). Two weeks after treatment, there was nearly a 100% increase in total sterol in treated plants over that of controls. Four weeks after treatment, an increase was noted in sterol content of 100  $\mu\text{g/ml}$  treated plants (19.8  $\mu\text{g/mg}$  lipid) compared to that of controls (13.2  $\mu\text{g/mg}$ ), but a decrease in sterol content of 500  $\mu\text{g/ml}$  treated plants (7.87  $\mu\text{g/mg}$ ) was observed. This data supports the hypothesis that the effect of Cycocel on sterol synthesis is dependent on concentration and stage of development of the plant.

EXAMINATION AND EVALUATION OF GERMINATION AND PROTONEMA DEVELOPMENT FOR *ONOCLEA SENSIBILIS* SPORES TREATED WITH AFLATOXIN B<sub>1</sub>. S. G. Cahill\*, J.D. Reynolds, R.W. Fisher\*, and G.C. Llewellyn. Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284

Experiments were designed to test the effects of aflatoxin B<sub>1</sub> (AFB<sub>1</sub>) on germination and subsequent development of the gametophytes of the sensitive fern *Onoclea sensibilis*. AFB<sub>1</sub> concentrations used were 0, 2.5, 5.0, 7.5, 10.0, and 12.5  $\mu\text{M}$ .

Preliminary studies indicated that, under all AFB<sub>1</sub> concentrations tested, germination was maximum after 144 hrs. Additional studies revealed that during this time period protonemal growth was in log phase.

Percent germination was inhibited by increasing concentrations of AFB<sub>1</sub>; a 50% inhibition was noted at 12.5  $\mu\text{M}$ . In addition, increasing concentrations of AFB<sub>1</sub> caused a reduction in the total number of cells per protonema. Preliminary analysis indicated that this was caused by a reduction in the rate of cell production rather than total inhibition of cell division. A comparison of the dose-response curves for both of the above effects demonstrated that sensitivity to AFB<sub>1</sub> starts at 5.0  $\mu\text{M}$ . This may indicate that AFB<sub>1</sub> is acting on a process common to both phenomena.

The fern spore germination system could be a "simple" model system in which to study the site and mode of action of AFB<sub>1</sub>.

SECONDARY SUCCESSION AND PRESCRIBED BURNING AT BIG MEADOWS, SHENANDOAH NATIONAL PARK. W. D. Cocking, E. Baxter\*, and S. Lilly\*. Dept. of Biology, Madison College, Harrisonburg, Virginia 22801

Most non-forested open space within the Shenandoah National Park is a result of secondary succession following agricultural land use. Some areas have been mowed each fall for over a decade to maintain a vegetation mosaic including forested, shrubby, and herbaceous communities. This is an increasingly expensive endeavor. A limited test of the use of prescribed burning to stabilize communities at early seral stages was reported by the authors last year. Significant reductions in both cover and biomass were obtained without deleterious effects. Regrowth of diverse plant communities following fire management was both rapid and extensive.

Treatment areas were increased from eight 50 meter square plots in the 1975 to burns of over 10 ha. in 1976 and in March of this year. We feel that a management plan which allows for irregular burn boundaries, regrowth between burns to promote fruit production of *Rubus* spp. and *Vaccinium* spp., and periodic repeated spot burning within briar-shrub patches to establish herbaceous pattern is an economical and environmentally sound approach. In its absence, forest encroachment will ultimately eliminate numerous "open space" plant and animal species from within the park boundaries.

THE VASCULAR FLORA OF THE JONES AND MILL CREEK WATERSHED, POWHATAN COUNTY, VA. Celeste M. Corcoran\*, College of William and Mary, Williamsburg, Va. 23185

This floristic study in the southern Virginia piedmont began in February 1976, and is presently continuing. The study area is in northeast Powhatan County and encompasses twenty-five square miles.

Some of the more unusual habitats in the study area include rocky bluffs above the James River, several granitic rock outcrops, and an extensive swamp and millpond system. Each of these habitats yielded interesting and characteristic species, some of which are not commonly found in the Virginia piedmont.

As of April 1977, over 750 species have been collected and identified, the majority of which are Powhatan County records. A number of rare species have been collected and many distributional records have been recorded. The most significant find is a grass new to Virginia, *Eriochloa gracilis* (Fourn.) Hitch.

AN EVALUATION OF THE CONCEPT OF NUTRIENT CYCLE TIGHTNESS IN ECOSYSTEMS. F. P. Day, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Establishing ecosystem principles and indices is an important research goal in the field of ecology. Nutrient cycle tightness, the ability of ecosystems to retain nutrients, is a feature of ecosystems which has been treated vaguely in the ecological literature; consequently, some controversy and confusion have resulted. A review of the literature indicates the existence of two different basic concepts, with tightness implying cycling efficiency or degree of leakiness. This paper presents a proposed index of tightness involving ecosystem nutrient capital/ecosystem output. Successional trends in tightness based on the different concepts are evaluated and the functional reality of these trends is discussed.



UPTAKE AND TRANSLOCATION OF BENOMYL IN PIN OAK (QUERCUS PALUSTRIS Muenchh.). Glenn B. Dawson, R. J. Stipes and M. S. White. Departments of Plant Pathology-Physiology and Forestry-Forest Products, VPI & SU, Blacksburg, VA 24061.

Uptake and translocation of benomyl in pin oak following application to intact bark and lateral pruning wounds were observed. Formulations assayed included 5,000 ug/ml benomyl in 1) water, pH 2, 2) water, pH 6.8, 3) water, pH 12, 4) diethyl ether, 5) dimethyl sulfoxide, 6) acetone, 7) chloroform and 8) a 1:1 mixture of diethyl ether and dimethyl sulfoxide. Solvents and pH values were selected because of their known or suspected potential in enhancing penetration into and through bark. Formulations were applied to intact bark by injecting a solution or suspension onto gauze tightly wrapped around a lateral branch; a polyethylene plastic sleeve over the gauze diminished evaporation. Formulations were also applied to decapitated lateral branches to simulate wound paint application as used to prevent wound colonization by fungal pathogens.

Bark and wood tissues were sacrificed and bioassayed qualitatively by standard laboratory methods, using Penicillium expansum as the test organism.

Although organic solvents enhanced bark penetration, phytotoxicity was evident in every case of penetration. No translocation beyond the site of uptake (penetration) was evident in either bark or wound applications as determined by the model system employed.

THE RARE OPHIOGLOSSUM VULGATUM L. IN THE NORTHERN MASSANUTTEN MOUNTAINS. Louise E. Diven\* and Norlyn L. Bodkin. Dept. of Biology, Madison College, Harrisonburg, VA 22801

A new station for Ophioglossum vulgatum L. has been located in Mudhole Bog, Powell's Fort Valley, in the northern Massanutten Mountains of Shenandoah County. The plants were found in a sphagnum bog-like habitat which contains a number of other rare plant species.

Two varieties, O. vulgatum variety pycnostichum Fernald and O. vulgatum variety pseudopodium (Blake) Farwell have been traditionally recognized by pteridologists. The variety pycnostichum is most widely distributed in the state east of the Blue Ridge Mountains, while the variety pseudopodium is restricted to one location in Highland County. The typical habitat for the common variety is dry calcareous woods, in contrast to pseudopodium which grows under wet, acidic, sphagnum conditions. The specimens collected in Mudhole Bog superficially resemble the variety pycnostichum with possible intermediates, however, the bog habitat is more characteristic of the variety pseudopodium. This preliminary research indicates that these plants need more extensive taxonomic study before a new station of either variety can be definitely established.

EFFECT OF CIBA-GEIGY'S EXPERIMENTAL HERBICIDE CGA-24705 ON NUTRIENT UPTAKE IN ZEA MAYS (NORTHUP KING 199 SWEET CORN VARIETY). T.W. Ellis\* and K.K. Nesius. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

The effect of the herbicide CGA-24705 on uptake of magnesium, calcium, phosphorous and potassium by Zea mays (N.K. 199) was studied. Zea mays was grown hydroponically using thirteen different concentrations of CGA-24705 ranging from 0.0 to 3.2 ppm. After ten days of treatment the plant tissue was analyzed to determine the percentage of magnesium, calcium, phosphorous and potassium in the tissue and the amount uptake of these elements through the root system. There was little change in the percentage of these elements in the tissue with the exception of calcium which increased from 2.36 at 0.0 ppm to 4.54 at 3.2 ppm. At high concentrations of the herbicide the amount of phosphorous, calcium, and potassium uptake decreased. Root growth was also stunted at higher concentrations of the herbicide. (Aided by CIBA-GEIGY Corp.)

A QUANTITATIVE ANALYSIS OF THE LARGE WOODY LITTER IN FOUR MAJOR COMMUNITIES OF THE GREAT DISMAL SWAMP. Louise M. Erskine\*, Dept. of Biology, Randolph-Macon Women's Col., Lynchburg, Va. 24503 and Frank P. Day, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

The Great Dismal Swamp is a heterogeneous pattern of vegetational communities. These different communities have been subjected to varied amounts of alteration by man, resulting in differences in structure. The large woody litter was sampled quantitatively in four of these communities and comparisons were made. The Atlantic white cedar (Chamaecyparis thyoides) and cypress (Taxodium distichum) stands had the largest mass of woody litter (43,650 kg/ha and 47,403 kg/ha respectively). The maple-gum (Acer rubrum-Nyssa spp.) and mixed hardwood stands had significantly less woody litter (25,423 kg/ha and 7386 kg/ha respectively). Stand age and environmental variation are probably the primary causes for the structural differences.

MORTALITY OF WHITE OAK FRUITS IN PATRICK COUNTY, VIRGINIA. P. P. Feret, R. E. Adams, R. E. Kreh\*, and T. A. Munsey\*. Dept. of For. and For. Prod., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Acorn production and variation in acorn production have long been of interest to wildlife biologists and foresters. Detailed observation of developing acorns on two trees at the Reynolds Homestead Research Center suggest that acorn mortality is greatest during the interval between pollination and fertilization, that the rate of acorn mortality decreases over time, and that although trees differ in total productivity, causes of mast failure are the same. Possible causes of acorn mortality are discussed.

PERFORMANCE OF PITCH PINE X LOBLOLLY PINE HYBRIDS IN PATRICK COUNTY, VIRGINIA. P. P. Feret, R. E. Kreh\*, T. A. Munsey\*, and J. A. Ramsey\*. Dept. of For. and For. Prod., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

In May 1975, three replicates of a Pinus rigida x taeda planting supplied by F. Trew (Westvaco) and S. Little (USFS) were planted. The planting consisted of 53 full-sib crosses, Virginia Division of Forestry loblolly and pitch pine controls, Korean pitch x loblolly pine hybrids and 4 open-pollinated families planted in 10 tree row plots. Plantation survival after the first year was 76.4% and overall average height was 28 cm. At the end of the second year plantation average height was 71 cm and survival 65%. The best 15 % of the hybrid pine crosses were at the end of the first year, 36% taller than the loblolly pine control and after 2 years 22% taller. The best cross (59 x 7-56) was 68% taller than loblolly pine and 50% taller than the plantation average after the first year while comparable figures for the second year were 56% and 45%.

EFFECTS OF ELEVATED ATMOSPHERIC CONCENTRATIONS OF OXYGEN ON LEVELS OF CORN LEAF SUPEROXIDE DISMUTASE. Joyce G. Foster and John L. Hess. Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

In investigating how plants deal with environmental  $O_2$ , we have determined the effect of elevated levels of atmospheric  $O_2$  on forms and quantity of leaf tissue superoxide dismutase (SOD), an enzyme which catalyzes the dismutation of  $O_2$ .

Corn seedlings, Zea mays, cv. Pioneer 3369 A, were grown 2-3 weeks at 28-30° under high light intensities (16 hr/day) and normal atmospheric conditions or atmospheres enriched to 45%  $O_2$  for 1 week. Heat stable, soluble protein extracts from green and etiolated tissues exhibited four major bands of SOD activity having relative mobilities 0.35, 0.47, 0.58, and 0.95 on 7% polyacrylamide gels electrophoresed at pH 8.9. Only the band having a mobility of 0.58 was insensitive to  $CN^-$  (20% of total activity), a property of mitochondrial SOD in eucaryotes. These forms of the enzyme remained qualitatively similar after exposure of plants to elevated  $O_2$ , and no long-term change in the total amount of SOD present in green or etiolated leaves was observed:

specific activity	units/mg protein	units/g tissue
tissue type	green etiolated	green etiolated
control	9 23	99 101
1 week: 45% $O_2$	9 23	106 96

Apparently constitutive levels of SOD in corn leaves is sufficient to deal with increases in  $O_2$  concentrations at elevated  $O_2$ . (Supported by CSRS Grant 316-15-93).

HERBICIDES: TOOLS OF MODERN AGRICULTURAL TECHNOLOGY. C. L. Foy. Dept. of Plant Pathology and Physiology, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The combined annual costs and losses attributed to weeds in the U.S. are approximately \$11 billion, exceeding those of any other group of agricultural pests. Losses caused by undesired vegetation in Virginia are estimated at \$125 million. Thus, weeds profoundly influence human affairs and should be the business of all consumer-citizens. Synthetic organic herbicides are now accepted "prescription tools" of modern agricultural technology, essential for the continued efficient production of food and fiber for the world's expanding population. Literally hundreds of herbicidal chemicals, formulations and proprietary products are now on the market. Currently about 11,000 new compounds are synthesized and screened, over a period of 88 months, and with an expenditure of \$16 million, before approval of the first label or sale of a new pesticide. Regulations are overly restrictive. Nevertheless, herbicide development and use continue to increase because of economic need. Herbicides now comprise 64-65% of the total value of sales of all pesticides and growth regulators, far exceeding the combined value of all others. Used judiciously, herbicides are compatible with the preservation and enhancement (rather than the sometimes alleged deterioration) of environmental and life quality.

THE VASCULAR FLORA OF GLOUCESTER COUNTY, VIRGINIA.

Jim Greaves\*. Dept. of Biology, The College of William and Mary, Williamsburg, Va. 23185.

A floral survey of the county was begun in June 1975, and will continue through the summer of 1977 in order to complete a collection of the woody angiosperms. Primary emphasis in the study was placed on the Beaverdam Swamp drainage in the center of the county, roughly 34 square miles. This is the first major survey of this kind on the Middle Peninsula since John Clayton's time.

Freshwater ponds, swamps, pine stands, open beech-oak-hickory forests, and cultivated fields and yards comprise the habitat types in and around the Beaverdam. Some roadsides throughout the county were studied, and two trips were made into salt marshes below Gloucester Point on the York River.

As of April 1977, over 645 taxa in 117 families had been identified, of which over 430 are new for the county record. One species previously unrecorded in the state was Leontodon nudicaulis, and at least one major disjunction was discovered in Viola conspersa. Other plants of interest include Woodсия obtusa, Lycopodium lucidulum, Potamogeton crispus, Lychnis coronaria, and Galax aphylla.

FACTORS AFFECTING THE DISK BIOASSAY TECHNIQUE IN FUNGICIDE EVALUATION. D. B. Janutolo and R. J. Stipes. Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

The disk bioassay technique (DBT) is often employed to evaluate the qualitative and quantitative response of a chemical to a microorganism. In the present study, several factors affecting a model DBT system were examined. The basic DBT consisted of placing a 13-mm bioassay disk containing 100  $\mu$ l of a 100  $\mu$ g/ml solution of methyl-2-benzimidazolecarbamate phosphate on a glucose-yeast extract agar (GYEA) plate, surface-seeded with spores of Ceratomyces ulmi (VPI & SU Culture No. VA 32). The plate was first incubated at 4 C to allow diffusion of the toxicant, then at 25 C to allow growth of C. ulmi. The zone of inhibition (ZOI) was then recorded. Keeping all other variables constant, in Test I the GYEA plates contained varying depths of agar with 5, 10, 15 or 20 ml/plate. In Test II, different concentrations of agar (1.0, 1.5, 2.0%) in the GYEA were tested. In Test III, plates were incubated at 4 C for various time periods ranging from 0 - 96 h. Test IV consisted of examining the effect of glass vs. plastic Petri dishes on DBT.

The increase in size of ZOI was inversely proportional to an increase in quantity of agar per plate, whereas it was directly proportional to an increase in incubation time at 4 C. Percentage of agar and type of dish had no significant effect on the ZOI.

AN EVALUATION OF AFLATOXIN OCCURRENCE IN PEANUTS. Ronald H. Johnson and Gerald C. Llewellyn. Department of Biology Virginia Commonwealth University, Richmond, VA 23284

Peanuts are an important agricultural product which are used for both human and animal food and feed. A group of toxic and carcinogenic agents resulting from the fungal growth of Aspergillus flavus has been detected in peanuts and other stored products. Since November of 1964 the levels of aflatoxins in samples of shelled peanuts from Virginia farms have been monitored by the Department of Agriculture and Commerce. The data from 9 1/2 years of such monitoring has been summarized. The study to be presented finds two major monthly peaks of aflatoxin occurrence. One in May-June and the other in October-November. The possibility of correlations between climate--temperature and rainfall-- and occurrence will be presented with the intent of establishing a predictor-model.

TYPE AND FREQUENCY OF FUNGI IN AND ON PISTILLATE FLOWERS OF WHITE OAK (QUERCUS ALBA L.). M. X. Kolpak\*, P. P. Feret, R. J. Stipes, and R. E. Adams. Dept. of For. and For. Prod. Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Three genera of the Fungi Imperfecti - Alternaria, Cladosporium and Epicoccum - occur in high frequency on the pistillate flowers of white oak. These fungi are common forest saprophytes and are generally found in the microflora of the forest ecosystem. Numerous other genera were isolated in addition to these, but they occur in very low frequencies. Some of the genera isolated include: Ulocladium, Pestalotia, Fasarium, Aspengillus, Nigrospora and Curvularia.

Flowers were collected from four mature white oaks, two located in the Virginia Piedmont near Critz, VA and two in the Ridge and Valley Province of southwest Virginia near Blacksburg, VA. Pistillate flowers were collected aseptically during the period of pollen dispersal and inoculated onto a general culture media (potato dextrose agar).

Frequency of occurrence of the major fungi varied although the same genera occurred in the highest frequencies at both sample areas. Further tests have been designed to investigate the possibility that these fungi may directly influence the success of the yearly acorn crop through inhibition of pollen germination.



LITTER ACCUMULATION IN NATURALLY SEEDED VIRGINIA PINE (*PINUS VIRGINIANA* MILL.) STANDS. R. E. Kreh\*, R. B. Vasey, and H. A. T. Madgwick\*<sup>1</sup>. Dept. of For. and For. Prod., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Litter-fall and litter-layer data were collected from stands of 7, 13, 19 and 36-year-old naturally seeded Virginia pine (*Pinus virginiana* Mill.). The pattern of yearly litter-fall was highly seasonal with maximum needle-fall occurring during the fall months. The range of annual total litter-fall was 294 to 558 g/m<sup>2</sup> dry weight which increased with stand age. The percent annual contribution of non-needle material to the total litter-fall increased from 17% in the 7-year-old stand to 44% in the 36-year-old stand.

Maximum litter-layer dry matter weight of 13.9 Kg/m<sup>2</sup> and volatile matter weight of 5.2 Kg/m<sup>2</sup> occurred in the 26-year-old stand. The depth of the litter-layer increased with stand age to a maximum of 5.3 cm in the 36-year-old stand.

Three models characterizing the accumulation and decomposition of litter were developed. The best fitting models assumed that the rate of litter decomposition decreased with increasing litter age and that litter-fall increased with increasing stand age for at least the first 36 years.

(Sponsored through the Reynolds Homestead Research Center)

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PHYTOPLANKTON DISTRIBUTION ALONG THE EASTERN COAST OF THE UNITED STATES. H. G. Marshall, Dept. Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

Phytoplankton composition, succession, and seasonal assemblages were identified in neritic waters off the eastern coast of the United States. The data base came from collections made at 542 stations from 22 cruises between Nova Scotia and Florida over a ten year period. Over 600 phytoplankters were identified. Seasonal succession patterns indicated a diatom flora dominated the neritic waters from late fall to early spring, then a change in the major species occurred during late spring and summer when a combination of diatoms and phytoflagellates dominated the collection. The more seaward collections were dominated by phytoflagellates. Progressive seasonal composition changes were noted along north-south collection transects during the changing seasons, advancing southward during the winter months, then moving northward in late summer, with current systems along the coast influencing the distribution patterns. Movements of the Gulf Stream and eddy formation provided entry of tropical species into waters north of Cape Hatteras. Cape Hatteras was associated with the separation of boreal and temperate phytoplankters to the north from the subtropical-tropical species. Characteristic assemblages of phytoplankton were common to cold and warm waters, and the seasonal changes along the coast. The research was supported in part by NSF grant GA 31768.

VEGETATION SAMPLING DESIGNS FOR ASSESSING THE EFFECT OF WHOLE TREE HARVESTING ON MIXED OAK-PINE STANDS IN THE RIDGE AND VALLEY PROVINCE OF VIRGINIA. T. J. McEvoy\*, Terry L. Sharik, and D. W. Smith\*. Dept. of For. and For. Prod., Va. Poly. Inst. and State Univ., Blacksburg, VA 24061

Various sampling designs used to assess structure, composition, and productivity of vegetation in mixed oak-pine stands before and after a whole tree harvesting clearcut are discussed. The study areas are located in four non-contiguous compartments varying in size from 7.5 ha. to 17.3 ha. Merchantable material is to be removed from the compartments by a skyline cable system, and chipped for transport to the pulp mill. Criteria and methods for sample plot size and location are discussed relative to vegetation homogeneity within the four basic vegetation types present in the compartments. Sample plots within areas were established on the basis of a nested design to accommodate measures of vegetation by height strata. Location of plots and individuals of major species within plots by a grid matrix should permit a three-dimensional mapping of all major species. Structural measurements in various strata will be used to test relationships, through regression techniques, with biomass, productivity and nutrient levels determined from destructive sampling in adjacent plots.

SURVEY OF THE VASCULAR AQUATICS OF ORANGE COUNTY, VIRGINIA. H. B. Lantz, Jr. Orange County Public Schools, Orange, Va. 22960

Floristic studies on vascular aquatic plants are sadly lacking for the state of Virginia, and, in particular, Orange County. During the past eight years, the author has been involved in surveying aquatic genera, with particular interest in distribution patterns within Orange County and adjacent mountain and piedmont counties. The range for several species has been extended as a result of this study. Furthermore, it has been determined that some species are much more common than had been previously reported.

BETULA UBER - THE PRESERVATION OF ITS GERMPLASM. Peter M. Mazzeo. Herbarium, U.S. Nat. Arboretum, Agri. Res. Service, U.S. Dept. of Agri., Wash. D.C. 20002.

*Betula uber*, the rarest birch species indigenous to the United States, and long thought to be extinct, was discovered in 1975. Since only 15 mature trees and 21 seedlings were found in one natural population that is in a threatened location, the National Arboretum, as part of its plant distribution program, is propagating the *B. uber* germplasm in an attempt to save the species from extinction. Cuttings from seedlings growing at the National Arboretum and seed collected from the indigenous trees were successfully propagated for the first time in 1976. When sufficient material of *B. uber* is available, it will be distributed to other arboreta and botanical gardens around the world.

In addition to the propagation of more plant material, attempts are being made to protect the natural population of *B. uber* in Smyth County, Virginia.

CHANGES in the COMPOSITION and ACTIVITY of CELLULASE in the MEDIA of *ACHLYA BISEXUALIS* GROWN on GLUCOSE, CELLOBIOSE and CELLULOSE. W. H. Miele\* and A. E. Linkins. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The antheridial strain of *A. bisexualis* was grown in shake culture producing typical linear dry weight accumulations in glucose cultures with high levels of soluble cellulase in the media. Growth with cellobiose has greater dry weight accumulation, but low cellulase activity in the media until stationary phase where levels increase. With cellulose dry weight accumulations continue for 4-5 days and then decrease to low levels within 24 hours. Addition of fresh cellulose causes another peak-decline cycle to occur. Soluble levels are low until the dry weight declines, then it increases. Examination of the cellulose substrate shows that high ionic strength buffer will solubilize cellulase. The amount solubilized is directly proportional to the accumulation of growth in the medium. SEM examination of the walls of *A. bisexualis* shows fibrillar disruption in cellulose grown hyphae, which is not evident for glucose or cellobiose grown hyphae. This evidence suggests that cellulase produced during growth on cellulose is capable of binding as an active hydrolase to walls of *A. bisexualis* or to the cellulosic substrate.

EMBRYO CONTROL OF ISOCITRATE LYASE ACTIVITY IN MEGAGAMETOPHYTE TISSUE OF PONDEROSA PINE SEEDS. E. W. Murray\*, R. E. Adams, and P. P. Feret. Dept. of For. and For. Prod., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The specific activity of isocitrate lyase (threo-D<sub>5</sub>-isocitrate glyoxylate-lyase, EC 4.1.3.1.) from megagametophyte of *Pinus ponderosa* increased to a maximum at eight to ten days then declined. Contrary to previously published data, the rate of increase in specific activity of embryoless seeds was greater than in seeds with intact embryos during the first four days. A similar pattern of activity was observed in seeds which retained their embryos for two days to allow germination to occur prior to excision, but the maximum activity reached was slightly higher, and the cycle of enzyme development and decline lasted two days longer. A diffusate prepared from two day germinated embryos had no significant influence on the enzyme activity of embryoless seeds.

These phenomena were not dependent on stratification. Imbibition was the only prerequisite for germination and development of enzyme activity to occur.

A discussion of the possible mechanisms controlling this pattern of enzyme activity will be included. Factors which may have contributed to the discrepancies between these results and previously published data will be discussed.

NON-PROTEIN NITROGEN IN VASCULAR PLANT DETRITUS. W. E. Odum\*, J. C. Ziemann\*, G. Arrill\*, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903, and P. W. Kirk, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

It has been generally assumed that microbial protein accounts for nearly all of the increase in nitrogenous content of decaying vascular plant detritus. This assumption has been derived mainly from estimates of "crude protein" determined in the usual manner as total micro-Kjehldahl nitrogen times a factor of 6.25. However, the Kjehldahl digestion liberates ammonia from a number of naturally occurring substances in addition to protein, notably glucosamine which we have attributed to the chitinous cell walls of filamentous fungi that occur conspicuously on decaying *Spartina cynosuroides* and other vegetation. By rigorous extraction of protein prior to Kjehldahl analysis, non-protein nitrogen was shown to comprise as much as 52% of the total nitrogen content of plants decaying under aerobic conditions which favor the development of fungi. Invertebrate chitin was not apparent in the samples, but other resistant nitrogenous substances such as protein-lignin complexes have not been excluded. This research was supported by NSF grant GA34100.

GROWTH AND DEVELOPMENT OF DRYOPTERIS GAMETOPHYTES IN CULTURE. J. M. Pitchford\*, J. G. McHaffie\*, D. W. Sampson\* and L. J. Musselman, Dept. of Biological Sciences, Old Dominion Univ.

Spores from several species of *Dryopteris* were sowed on peat and incubated at 25°C with 10 hours of light daily. *D. X separabilis*, a triploid, produced viable gametophytes. These produced sporophytes apparently by selfing. Gametophytes of *D. celsa*, *D. spinulosa*, *D. intermedia*, and *D. cristata* produced abundant gametophytes followed by sporophytes when properly fertilized. They also regenerated viable gametophytes from the parent gametophytes. These gametophytes were of two forms: cordate and filamentous. The filamentous were strictly antheridial.

(Supported by grant from National Geographic Society.)

LOG FERNS AND THEIR RELATIVES IN THE GREAT DISMAL SWAMP, L. J. Musselman, \*D. W. Sampson, \*J. M. Pitchford, and \*J. G. McHaffie, Dept. of Bio. Sci., Old Dominion Univ., Norfolk, Va. 23508.

The Great Dismal Swamp has been an area of great interest for log ferns for almost a century. However, it has only been in the past year that some of the more inaccessible areas of the swamp have been carefully studied. The following taxa are now known to be extant in the swamp:

*Dryopteris intermedia* (the only diploid), *D. spinulosa*, *D. cristata*, *D. celsa*, *D. celsa* x *D. cristata* (all allotetraploids), *D. X australis*, *D. X separabilis*, and *D. X triploidea* (triploids). Two other taxa have also been reported from the swamp. The first, *D. marginalis*, is known from a single specimen taken in 1899 and has not been collected since. The second, *Dryopteris atropalustris*, is now considered to be an aberrant form of *D. celsa* in which the fronds are mechanically damaged during development.

Our studies suggest that human activities within the swamp have favored the expansion of existing populations and encouraged the establishment of new populations. This is indicated by the spread of log ferns on road banks and by the increase of population sizes in areas where the water table has been lowered.

(Supported by NSF-URP SMI76-01237.)

A WETLANDS FOREST SIMULATOR. R. L. Phipps. Tree-Ring Lab, M.S. 461, U. S. Geological Survey, Reston, Va. 22092

A computer program, SWAMP, has been constructed to simulate the effects of hydrologic conditions - flood frequency and depth to water table - on southern wetlands forest vegetation dynamics. By including hydrologic conditions the model simulates consequent forest vegetation and vegetation dynamics. The model, based on data from the White River National Wildlife Refuge near Dewitt, Arkansas, "grows" individual trees on a 20-by-20 meter plot taking into account effects of flooding, depth to water table, shade tolerance, overtopping, crowding, and probability of death and reproduction. A potential application of the model is illustrated with simulations of the effects of flood-control implementation and lumbering on the production of acorns and other fruits eaten by wildlife. (Aided by Contract 14-16-0008-1107: U. S. Fish and Wildlife Service)

COLOR REACTIONS AND COLOR DEVELOPMENT IN ENDOTHIA. M. K. Roane and R. J. Stipes, Depts. Biology and Plant Pathology and Physiology, VPI & SU, Blacksburg, VA 24061.

Production of perilla purple on white cornmeal medium (WCM) by cultures of *Endothia eugeniae* and *E. japonica* is reported for the first time and is corroborated for cultures of *E. fluens*, *E. gyrosa* and *E. singularis* as reported by Shear et al. (USDA Bull. 380. 1917). There was no production of perilla purple by *E. havanensis*, *E. longirostris* (as reported by Shear et al., 1917), *E. macrospora*, *E. parasitica*, *E. tropicalis* or *E. viridistroma*. Color developed in aerial mycelium on WCM in the sequence: white → tan → orange → chestnut and in submerged mycelium and medium: no change → lemon yellow → chartreuse or orange → perilla purple or brown. Much the same pattern of color change for aerial mycelium occurred on glucose yeast extract broth. There was a purple color reaction in the solution when compounds were extracted by dropwise addition of 5% KOH or NH<sub>4</sub>OH to mycelia of *E. eugeniae*, *E. fluens*, *E. gyrosa*, *E. macrospora*, *E. singularis*, and *E. tropicalis*. Under the same conditions a maroon color was formed in solution from substances extracted from mycelia of *E. havanensis*, *E. japonica* and *E. parasitica*. Mycelium of *E. viridistroma*, normally dark olive, turned yellow brown in the presence of these bases. Comparisons were made of color reactions of the ascus apical ring in Melzer's solution and in cotton blue. These color observations may be useful taxonomic adjuncts.



FUNGAL ASSOCIATES OF PARASITES OF CERTAIN SPECIES OF FAGACEAE. M. K. Roane and R. J. Stipes, Depts. of Biology and Plant Pathology & Physiology, VPI & SU, Blacksburg, VA 24061.

A parasitic scale insect (*Melanaspis obscura*), its fungal parasite (*Nectria dichloa*), one of several species of *Ceratocystis* and *Hypoxyton atropunctatum* were often found associated closely with species of the fungal genus *Endothia* on twigs and branches of members of the Fagaceae. *Endothia parasitica* occurred with *Ceratocystis coerulea* on *Castanea dentata*, with *Ceratocystis capillifera* on *Castanea mollissima* and with *Ceratocystis minuta* on *Quercus phellos*. Obscure scale, *M. obscura*, and the fungi, *E. gyrosa* and *H. atropunctatum*, were found on *Fagus grandifolia*. The scale was also found with *E. gyrosa* on *Q. suber* and *Q. palustris*. *Nectria dichloa* was parasitic on obscure scale on *Q. palustris* which was also infected with *E. gyrosa*. The parasitic, hyperparasitic or saprophytic associations may be related to transmission, host predisposition and succession phenomena.

PROPERTIES OF GLYCOLATE OXIDASE (1.1.3.1) FROM DIFFERENT COTTON VARIETIES. Philip N. Russ\* and John L. Hess. Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061

Glycolate oxidase, a flavoprotein which catalyzes the reaction,  $\text{glycolate} + \text{O}_2 \rightleftharpoons \text{glyoxylate} + \text{H}_2\text{O}_2$ , is important in photorespiring  $\text{C}_3$  plants. We have examined the cotton enzyme through kinetic analysis and isoelectric focusing. Glycolate oxidase was isolated from the leaf tissue of two cotton varieties, 2485 and Coker 310, and purified three fold using 50%  $(\text{NH}_4)_2\text{SO}_4$  precipitation of the soluble protein extract. The  $K_m$  for glycolate was 0.19 mM for the 2485 and 0.22 mM for the "Coker 310". FMN ( $10^{-4}$  M) addition did not enhance the activity of the partially purified oxidase from either variety. In contrast, FMN ( $10^{-4}$  M) addition stimulated the activity of glycolate oxidase from spinach and oat leaf tissue by 60%. Following isoelectric focusing of the partially oxidases from "2485" and "Coker 310" on thin-layer polyacrylamide slab gels (pH range 3-10) and staining of these gels for oxidase activity using diaminobenzidine, the major forms of the enzymes displayed isoelectric points in the range of pH 8.5-9.5. DEAE-cellulose (DE-52) chromatography at pH 9.0 corroborated the basic nature of these oxidases. Although similarities exist among the plant glycolate oxidases, the enzymes from cotton are distinctively different with respect to the nature of FMN association or binding. (Supported by CSRS grant 316-15-93).

ARTIFICIAL HYBRIDIZATION OF LOG FERNS AND THEIR RELATIVES. \*D. W. Sampson, \*J. M. Pitchford, \*J. G. McHaffie, and L. J. Musselman, Dept. of Bio. Sci., Old Dominion University, Norfolk, Virginia 23508.

*Dryopteris* has been intensively studied and hybrids between most species of Eastern North America have been well documented. One hybrid which has not been found in nature is that between *D. celsa* and *D. spinulosa*, both allotetraploids. Although *D. celsa* is one of the rarest ferns in North America, both it and *D. spinulosa* are common in the Great Dismal Swamp of Virginia and North Carolina. The swamp, then, is the only area in which both of these species occur in large numbers and would appear to be an ideal place to find their hybrid. However, a recent thorough search in the swamp failed to yield such a plant. The cytological and morphological characteristics of this plant are unknown; we are attempting to create it in the laboratory using controlled hybridization techniques.

(Supported by a grant from The National Geographic Society.)

CHANGES IN THE MYCOTA OF NORTHERN BACK BAY ACCOMPANYING A REDUCTION IN SALINITY. S. Schatz\*, Dept. of Botany, Univ. of R. I., Kingston, R. I. 02881, and P. W. Kirk, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Collections of cellulolytic fungi in northern Back Bay, Va. in 1972, and again in 1974-5, have provided a serendipitous demonstration of the relation between salinity and the predominating mycota of temperate waters. In both periods fungi were obtained by direct observation and incubation of submerged wood panels, driftwood and vascular plants. During 1972, when a salinity gradient of 3-31 ‰ was maintained by artificial pumping of seawater into the Bay, the mycota consisted 38% of marine Ascomycetes and 16% of marine Deuteromycetes with no aquatic Hyphomycetes found. In 1974-5, when pumping ceased and salinity ranged 0-2 ‰, marine Ascomycetes comprised 16%, marine Deuteromycetes 32%, and aquatic *Flagellospora* sp. was present. This supports estuarine distributional data and physiological studies which suggest that marine Ascomycetes are more competitive than Deuteromycetes at higher salinity levels despite the lack of a demonstrable requirement for sodium ion.

During both study periods the deuteromycetous *Monodictis putredinis* (Wallroth) Hughes appeared chiefly responsible for decay of Eurasian milfoil.

THE PURIFICATION AND CHARACTERIZATION OF CELLULOSE FROM THE SPORES OF *Dictyostelium discoideum*. L. A. Stein\*, A. E. Linkins\*, C. L. Rutherford, Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA. 24061.

Cellulase activity,  $\beta$ -1-4 glucan-4 glucanohydrolase, E. C. 4.3.2.1, has been isolated in the buffer soluble fraction of French pressure cell disrupted late spore stage of *Dictyostelium discoideum*. The bulk of the activity is isolated as a 100,000 dalton protein with an isoelectric point of 7.7. This was found to be exclusively an endoglucanase with no other  $\beta$ -1-4 glucanase activity present. Elution through a Concanavalin A-Sepharose column showed that it was a glycoprotein. Treatment of the semipurified or purified protein with n-butanol consistently fractionates the protein into its 100,000 dalton form and an active 10-20,000 dalton protein. This subunit is also a glycoprotein, is anionic, and is exclusively an endoglucanase. Since cellulase activity is membrane associated until late spore stage it is suspected that the 100,000 dalton cellulase is a glyco-lipo-protein aggregate which has its activity modulated by its lipid-membrane association during development.

CANKERING AND BLIGHTING OF LIVE OAK (*Quercus virginiana*) IN VIRGINIA. R. J. Stipes. Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Cankering and subsequent blighting of live oak (*Quercus virginiana*) by *Endothia parasitica*, the chestnut blight fungus, was first documented in 1960 in Colonial Williamsburg by May and Davidson. Later confirmation was made in 1965 by Gruenhagen and in 1971 by Stipes and Phipps. The disease has also been reported in Alabama, Florida, Mississippi, North Carolina and South Carolina.

Initial symptoms include loosening, cracking and sloughing of bark. A large callus circumscribing the lesion is commonly seen. Careful macroscopic examination of the exfoliated bark often reveals the characteristic orange-colored stromata of the fungus.

In a 1976 study of disease incidence in a population of 110 large live oaks at Hampton, Virginia, 87% were cankered, and the average number of cankers per tree was 8.5. One tree sustained 20 cankers, but individual lesion size and ramification thereof, rather than numbers of lesions per tree, often determined disease severity. Although death of individual branches was common, the blighting sometimes killed entire trees. Decay and discoloration fungi appeared to have gained entrance through cankered tissues, thus complexing and intensifying the original syndrome.

Surveys are continuing as well as studies on the biology and control of the disease.



ELECTROPHORETIC DIFFERENTIATION OF *Endothia fluens* and *E. parasitica*, INCLUDING THE HYPOVIRULENT STRAIN, ON ISO-ELECTRIC FOCUSED POLYACRYLAMIDE GELS. R. J. Stipes, M. K. Roane and D. Reigle. Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061 and LKB Instruments, Rockville, MD 20852.

General proteins of *Endothia parasitica* and *E. fluens* were fractionated and compared to determine their chemotaxonomic similarity. Mycelia of five isolates of *E. parasitica*, including the hypovirulent strain, and three isolates of *E. fluens*, cultured on glucose-yeast extract broth at 25 C for 2 wk were harvested and converted to acetone powders at -20 C. Soluble proteins from sodium bicarbonate extracts were separated by isoelectric focusing on LKB Instruments' PAGplate. The plate was composed of a gel conc. of 5%, cross-linkage of 3% and Ampholine of 2.4% (w/v) with a pH gradient range of 3.5 - 9.5. Electrofocusing was done at 4 C under constant power of 30 W and a maximum voltage of 1,500 V. Coomassie Blue R-250 stain was used to detect proteins. About 15-20 proteins were fractionated, and isolates of both species were readily differentiated visually by the presence of at least one heavily stained band at about  $R_f = 0.2 - 0.5$  in all *E. parasitica* isolates. The protein profile of the hypovirulent strain of *E. parasitica* is more similar to *E. parasitica* than to *E. fluens* profiles. Although the morphological differentiation of both taxa is in question, these data substantiate the present separation of the two species.

A SURVEY OF THE FLOWERING PLANTS OF THE APPOMATTOX RIVER FALL LINE BETWEEN MATOACA AND ETTRICK, VIRGINIA. C. Thomas, and M. Wilson. Dept. of Life Sciences, Va. State College, Ettrick, Va. 23803.

The flowering plants of the Appomattox River fall line are diverse and abundant. Three hundred and thirty-two species from ninety-three families have been identified in this survey. The overstory vegetation is climax forest with *Quercus* spp., *Ulmus* spp., *Celtis* spp., *Betula* spp., and *Acer* spp. dominant. Understory growth includes *Asimina triloba*, *Ilex* spp., *Viburnum* spp., *Clethra alnifolia*, *Rhododendrum* spp., *Vaccinium* spp., *Lindera benzoin*, and *Crataegus* spp.

THE VASCULAR FLORA OF THREE RIDGES MOUNTAIN, NELSON COUNTY, VIRGINIA. Francis Watson\*, Department of Biology, College of William and Mary, Williamsburg, Va. 23185

This study was begun in the spring of 1976 and is continuing at this time (April 1977), with over 500 taxa having been collected and identified. The area is located in the western area of Nelson Co., contains over 20 square miles, and elevations which range from 1000 to 3970 ft.

The area contains many interesting habitats which include small stream drainages, the flood plain of the Tye River, hardwood cove forests, small rock outcrops, cliffs and ledges, and a fairly extensive seepage area surrounding a stream head at 2600 ft. These areas yielded some interesting as well as characteristic species which will be discussed.

DISTRIBUTION OF *QUERCUS VIRGINIANA* MILLER IN SOUTHEASTERN VIRGINIA. E. Spencer Wise, Dept. of Biology and Environmental Science, Christopher Newport Col., Newport News, Va. 23606

*Quercus virginiana* Miller, live oak, has a natural range along the Gulf and Atlantic coasts from northeastern Mexico to southeastern Virginia. From Hampton, Va. south through Norfolk and Virginia Beach it once formed an almost continuous strip of maritime live oak forest. In Virginia this strip was restricted to a narrow band behind the dunes along the Chesapeake Bay and the Atlantic Ocean.

In addition to the maritime live oak forest remnants now remaining in Hampton, Norfolk, and Virginia Beach, there are small natural populations in Mathews and Northampton Counties. The Northampton County individuals are at the southernmost tip of the county, making the Mathews population the northernmost known one. A natural population may have existed in Newport News, but this is doubtful, since in Virginia it is a sand species.

Live oak has been widely planted as an ornamental in the areas adjacent to its natural range, and it has thrived where planted in Eastern Virginia. A number have been planted in Richmond, and one there is known to be 157 years old. One tree in Goochland County, west of Richmond, planted in 1935, has survived and grown. A young sprout in Westmoreland County apparently survived the recent cold winter. Apparently the species is hardy enough to survive and thrive some distance north and west of its natural range.

GLUTAMATE OXALATE TRANSAMINASE ISOZYMES IN THE MACROGAMETOPHYTE TISSUE OF *PINUS VIRGINIANA*. M. S. Witter\*, P. P. Feret, A. Esen, and J. Ramsey\*. Dept. of For. and For. Prod., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The technique of polyacrylamide slab gel disc electrophoresis was used to define segregating isozymes of glutamate oxalate transaminase (GOT) in the macrogametophyte tissue of *Pinus virginiana* seeds.

GOT appears to be controlled by two loci, locus A and locus B in *P. virginiana*. Locus A is variable with four clearly distinguishable alleles: A1, A2, A3 and A4. Slight positional shifts indicate there is additional variability in the A3 region with two forms of A3: A3<sub>1</sub> and A3<sub>2</sub>. Locus B is largely invariant. Allele B1 is the main band found in the trees examined. Two other rare allelic forms are B2, a positional shift and B<sub>N</sub>, an inactive form of the enzyme.

In a natural population, this enzyme system was found to be in Hardy-Weinberg equilibrium. In comparing three populations which approximately represent different levels of domestication, differences in allelic frequencies were found.

Population Dynamics of the Phytoplankton of Lake Chesdin, Virginia. B. R. Woodson, Kenneth Seaburg\*, Life Sciences Department, Virginia State College, Petersburg, Virginia

The phytoplankton of Lake Chesdin was observed to be quite diverse with 339 species and varieties identified. The dominant alga, *Melosira granulata* var *angustissima* displayed enormous pulses during fall and late spring at the shallower collection sites. The wide range in physical ecological factors such as sunlight, water temperature, and turbidity, during each season of the year caused tremendous variations in phytoplankton standing crop. Water temperatures ranged from an average of 30°C during late summer to 3.2°C during mid-winter which resulted from the shallowness of the lake and the small drainage area of the Appomattox River above Lake Chesdin.



## Section of Chemistry

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

### THE ACTION OF OZONE ON $\Delta^{9,10}$ -OCTALIN

Shelby K. Bailey, John M. Dean, III, William R. Schooley, James G. Sheridan, Jr., James K. Shillington (sponsor member) Earl W. Stradtman, Jr., Keith Allen Teel Dept. of Chemistry, Washington and Lee Univ. Lexington, Va. 24450

We have previously tried other routes to 1,6-cyclodecenedione, via  $\Delta^{9,10}$ -octalin, and have obtained poor results. One method involved oxidations by way of 9,10-decalindiol, using performic acid, saponification, and lead tetraacetate. The other used permanganate and acid conditions for a one-step oxidation. Recently we have built a simple ozonator, and we are hopeful that ozonolysis will afford a successfully clean method.

In an aqueous acetic acid suspension, ozone converts the octalin, which we have prepared in high yields, into the intermediate 9,10-ozonide, which subsequently hydrolyses to form the diketone. The crystals precipitate, are collected, and are recrystallized with acetone and with alcohol.

### A CNDO/S-CI ANALYSIS OF THE OPTICAL ACTIVITY OF 1-METHYLINDAN. S. Baldwin and D. Shillady, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

CNDO/S and optical activity calculations have been carried out on the axial-methyl and equatorial-methyl conformations of 1-methyl indan. All  $\pi-\pi^*$  plus the 30 lowest  $\sigma-\pi^*$  excitations were included; the resulting spectral predictions were in excellent agreement with experimental results by Schnepf. Bands in the 195 nm region were found to be sensitive to conformational changes and to arise from  $\sigma-\pi^*$  excitations neglected in previous calculations. Our calculated uv band positions are all within 2% of experimental maxima; all C.D. bands agree in sign from 260 to 180 nm.  $B_{2u}$ ,  $B_{1u}$  and  $E_{1u}$  analogues of benzene were identified. Our calculations indicate that Schnepf's CD spectrum corresponds to a weighted average of several conformations. For rigid structures, our calculations predict the 197 nm band will be positive for the axial position and negative for the equatorial. For non-rigid structures, the splitting of the states responsible for the 195 nm region is so small that vibrational considerations can change the sign of the CD bands in this region. The excellent fit of our uv assignments gives us renewed confidence in the CNDO/S method for hydrocarbons.

### SOME SUGGESTIONS ON THE USE OF THE COMPUTER AS AN INSTRUCTIONAL TOOL. James D. Beck, Chemistry Dept., Virginia State College, Petersburg, Va. 23803

Computer-based instruction has been used in secondary schools, colleges, and universities for a number of years, with chemistry being an area that has received considerable attention. A variety of instructional uses have been tried for computers, including tutorial work, drill-and-practice, simulations, games, on-line demonstrations, graphic display, and the generation of problem sets and examinations for individual use. At this point in time, the question may well be asked, "Why aren't computers being utilized more in chemistry classrooms?" There are a variety of answers to this question, some with merit and some that are presented more as excuses than real reasons. Some of these answers will be explored, along with suggestions for using the computer as an instructional tool. The author will draw upon his own experience in discussing some of the obstacles to using the computer and some possible ways to overcome these.

### COMPUTER-ASSISTED ANALYSIS OF NMR SPECTRA. H. P. Bell, Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Computer-assisted analysis of NMR spectra is used both in undergraduate and graduate spectroscopy courses at Virginia Tech. Two computer programs which are currently in use will be described. The first is Rothner-by's LAOCN-3, a program which assists in the analysis of complex spin-spin splitting patterns. In a typical application the student runs the proton spectrum of a disubstituted benzene derivative and then uses LAOCN-3 to determine the chemical shifts and coupling constants for the four aromatic protons. The second program, NMREX, was developed locally for the analysis of the two-site exchange problem. This program enables the student to determine activation parameters from experimental variable-temperature NMR data for such processes as the rotation of the carbon-nitrogen bond in amides and the chair-chair interconversion of cyclohexane derivatives. Both programs are written in FORTRAN and are easily transportable.

PURIFICATION AND MECHANISTIC STUDIES OF A NOVEL ENZYME FROM BAKER'S YEAST WHICH SELECTIVELY REDUCES  $\beta,\gamma$ -UNSATURATED KETONES. A. L. Bettag\* and O. R. Rodig, Dept. of Chemistry, Univ. of Virginia, Charlottesville, VA 22901

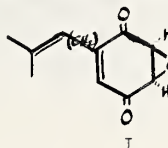
A partially purified  $\Delta^5-5\alpha$ -steroid reductase has been obtained from baker's yeast. This is a soluble enzyme which utilizes NADH as a cofactor. Mechanistic studies indicate that the enzyme possesses a novel selectivity, since it catalyzes only the reduction of  $\Delta^5-3$ -keto steroids, but not the reduction of the conjugated  $\Delta^4-3$ -keto steroids. The mode of reduction of  $\beta,\gamma$ -unsaturated ketones in most enzyme systems is believed to involve an isomerase reaction which converts the substrate to the more stable conjugated  $\alpha,\beta$ -unsaturated ketone. An enzyme which carries out the direct reduction of the double bond in the  $\beta,\gamma$  position is, therefore, quite unusual in this respect.

STUDIES ON QUINONE DIEPOXIDES. Donna Grey Booth\* and James B. Patrick, Mary Baldwin Col., Staunton, Va. 24401

Since supplies of 2,5-diprenylbenzoquinone were available to us as a by-product of another project, we planned a synthesis of its monoepoxide as an interesting prenyl-ogue of 7-desoxypanepoxydione (I). A model reaction, applying the perborate method of Rashid and Read to 2,5-dimethylbenzoquinone, unexpectedly gave the diepoxide, which we subsequently succeeded in separating into its *cis* and *trans* isomers. The properties of the new compound are reported.

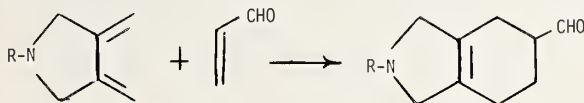
Since epoxydon, terreic acid, panepoxydon, and panepoxydione are tumor inhibitors, as are numerous natural epoxides reported by Kupchan, the quinone diepoxides are pharmacologically interesting.

Some observations on thymoquinone diepoxide, the earliest known member of this class of compounds, are also presented.



Novel Diels Alder Reactivity by N-Substituted 3,4-Dimethyl-ene-pyrrolidine by Homoconjugation. Henry Chin, Peter Alston, and Raphael Ottenbrite, Department of Chemistry, Virginia Commonwealth University, Richmond, Virginia.

Kinetic studies of several N-substituted-3,4-dimethylene pyrrolidines, prepared by thermal decomposition of the corresponding 1,3,4,6-tetrahydrothiophene 1,1-dioxides, have been carried out involving the Diels-Alder reaction with acrolein. Calculations of the frontier orbitals energies showed that the reaction was a near neutral Diels-Alder Type process. Rate data showed that electron withdrawing group substituted on the nitrogen increased the rate and electron donating groups on the nitrogen decreased the rate of reaction. CNDO calculations indicate that this change in rate was due to homoconjugation interaction between the bonded electron pair of the nitrogen and the LUMO of the diene.



RATES OF SPIN-FORBIDDEN ORGANIC REACTIONS. THEORETICAL STUDY OF THE RATE OF DIRECT PRODUCTION OF TRIPLET METHYLENE BY DISSOCIATION OF SINGLET DIAZOMETHANE. Sambhu Nath Datta\* Charles D. Duncan, H. Onder Pamuk\*, and Carl Trindle. Dept. of Chemistry, Univ. of Va., Charlottesville, Va. 22901

In order to test the possibility of direct production of triplet methylene by dissociation of diazomethane, we have adopted model potentials for singlet and triplet diazomethane and computed rates for singlet and triplet methylene production from a singlet precursor. The probability of surface crossing was described by the Landau-Zener formula; both a classical trajectory method and a statistical method were employed to evaluate rates, and the independent results indicated that the direct dissociation of diazomethane to  $N_2$  and triplet methylene could be competitive with the production of singlet methylene and its subsequent conversion to triplet. Production of a mixture of singlet and triplet methylenes would be difficult to rule out experimentally, since an Arrhenius plot would appear linear over a considerable temperature range.

VOLUME CHANGES OF MIXING AND PHASE DIAGRAMS FOR BINARY MIXTURES OF *p,p'*-DI-*n*-ALKYLOXYAZOXYBENZENES AND XYLENES. L. A. Delpire\*, M. E. Schott\*, P. J. Solensky\*, and R. A. Orwoll. Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

Volume changes of mixing and the temperature-composition phase diagrams have been studied for seven binary systems in which one component is one of the three isomers of xylene and the second component is a member of the homologous series of *p,p'*-di-*n*-alkyloxyazoxybenzenes. The methyloxy, pentyloxy, and heptyloxy derivatives were used. All three of the pure compounds exhibit a nematic mesophase; the heptyloxy homolog also has a smectic mesophase. The phase diagrams also show mesomorphic regions for solutions with low concentration of xylene (< ca. 30 mol-%).

Volume changes were found to be positive for the formation of anisotropic solutions. Isotropic solutions exhibit positive values of  $\Delta V_M$  at low concentrations of xylene and negative values at higher concentrations. The temperature coefficient of  $\Delta V_M$  is large and negative for isotropic solutions. (Supported by ACS-PRF Grant #8311-B5.)

METHYLATION OF 5.8S rRNA IN NORMAL AND TUMOR CELLS. H.C. Gay\*, and T.O. Sitz\*. Chem. Sciences Dept., Old Dominion Univ., Norfolk, Va. 23508., K.D. Somers\*, Dep't. of Microbiol., East Va. Med. School, Norfolk, Va. 23508, R.N. Nazar\*, Nat. Res. Council, Div. of Biol. Sciences, Ottawa, Canada K1A 0R6.

The sequence of 5.8S rRNA was determined in tumor cells from human, rat, and mouse (Biochem (1976) 15, 505). Two positions in the sequence were methylated in the ribose sugar (2'-O-methylation). One of these, -UmG-, was found to be a partial modification and was found in only 20% of the molecules, while another, -GmC-, was present in virtually all the molecules of 5.8S rRNA. When the methylation of the -UmG- position was examined in normal rat and mouse liver it was found to be elevated, 72% and 69% respectively, when compared to the tumor cell lines. Methylation levels were examined in a wide variety of normal and tumor cells and the -UmG-methylations was found to vary from 0.17 to 0.72 molar yield (FEBS letters (1975) 52, 83).

In an attempt to examine better controlled *in vivo* systems, preliminary studies have been initiated on the levels of 5.8S rRNA methylation in normal rat kidney (NRK) cells cultures, NRK cells infected and transformed by wild type mouse sarcoma virus (MSV), and NRK cells infected with a temperature-sensitive transformation mutant of MSV. Preliminary results demonstrate that MSV-transformed NRK cells have a reduced level of -UmG-methylation relative to uninfected NRK cells, 23% compared to 40%. There was no growth rate effect on this methylation.



IDENTIFICATION OF METAL-METAL BONDS IN ORGANO-METALLIC AND INORGANIC COMPLEXES USING INFRARED AND RAMAN SPECTRA UNDER EXTREME CONDITIONS SUCH AS HIGH PRESSURES AND LOW TEMPERATURES. A.M. Greenaway\*, C.J. O'Connor\* and E. Sinn. Dept. of Chemistry, Univ. of Va., Charlottesville, Va 22901

We are seeking to develop the use of Raman and infrared spectroscopy, over a range of pressures and temperatures, as a new technique for the detection, as well as the study, of metal-metal bonds in inorganic and organo-metallic complexes. The modifications of sample cells required for such work have become relatively simple. In particular, high pressure spectra are obtained by squeezing the sample between a pair of diamond anvils, which are transparent to the infrared beam. High pressures cause a contraction of the crystal lattice and thus affect the energies of vibrational modes, the most sensitive modes being those that effect a change in volume of the molecular unit. Low temperatures have a similar effect. Metal-metal stretching mode energies should therefore be especially dependent on pressure and temperature. Our preliminary results, on a series of compounds containing multiple order metal-metal bonds, support this prediction, and indicate the usefulness of the technique in the assignment of vibrational spectra.

IR AND NMR STUDIES OF CIS AND TRANS 1,2-CYCLOHEXANEDIOL - AN UNDERGRADUATE ORGANIC EXPERIMENT. Paul D. Henson, Gregory J. Leaf,\* and Gayle S. Goewey.\* Dept. of Chemistry, Roanoke College, Salem, Va. 24153

The synthesis and spectroscopic analysis of cis- and trans-1,2-cyclohexanediol provides an undergraduate experiment that demonstrates several important manifestations of organic stereochemistry: stereoselective reactions, cis-trans isomerism, and conformational analysis of cyclohexane derivatives. Cyclohexene can be stereoselectively converted to the cis- and trans-diols with potassium permanganate and hydrogen peroxide/formic acid, respectively. Infrared spectral studies indicate greater intramolecular and lesser intermolecular H-bonding for the O-H protons in the cis- than in the trans-diol and C-O stretching bands clearly demonstrate axial-equatorial arrangements for the cis-OH groups and equatorial-equatorial preferences for the trans-OH groups. NMR spectra are also consistent with the expected conformations. The ring protons (C-H) on carbon atoms 1 and 2 absorb at higher field for the trans-diol (axial-axial) than the cis (axial-equatorial) owing to shielding by the cyclohexane ring. The reverse is observed for the hydroxyl protons in nonproton-exchanging solvents (deuteriochloroform and deuterioacetone) where the cis-hydroxyl protons absorb at higher field than the trans, presumably because of different relative interactions of the groups.

Thermal Decomposition of Benzoate Esters in Solution. Pamela Jordon and Raphael Ottenbrite, Department of Chemistry, Virginia Commonwealth University, Richmond, Virginia.

p-Substituted benzoate esters of 1,1-diphenylpropanol were decomposed both neat (at 150°C) and in solution (at 100°C) to produce olefin and the corresponding benzoic acid. The neat decomposition produced near quantitative yields of olefin. The kinetics of the solution decomposition of these esters were studied by nmr spectroscopy. Decomposition carried out in pyridine solutions showed salt effects. Decomposition in less basic solvents, however, showed autocatalytic effects. The rate of decomposition increased with increasing dielectric constant. The energy of activation and entropy were determined for the benzoate and p-chlorobenzoate esters. The entropies were positive, +7.02 and +3.39 e.u., respectively, indicating a random transition state. A Hammett plot of sigma versus the logarithm of the rate constant of these esters yielded a rho value of +2.31 which is also indicative of a charge-separated transition state. It was concluded that the 1,1-diphenylpropyl-p-substituted benzoate esters decompose preferentially through an ion-pair mechanism rather than the concerted cyclic or free radical processes.

COMPUTER INTERFACING WITH CHEMICAL LABORATORY INSTRUMENTS - TRIALS AND TRIBULATIONS. J. F. Haw\*, J. M. Keller\*, and A. J. Diefenderfer. Dep't. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Interfacing a laboratory minicomputer to chemical instrumentation permits very high sampling rates, automated data processing and vast storage capabilities. Chemists beginning work in this field are initially immersed in an unfamiliar set of terminology and techniques. Work in progress is aimed at developing software and methodology to take advantage of computer capabilities. Thus far, an instructional mass spectrometer has been interfaced. Signal massaging, analog to digital conversion, pattern recognition, calibration and other necessary operations are discussed.

STUDIES OF THE NONPOLAR INTERACTION WITH COENZYME BINDING SITE OF CHICKEN MUSCLE ALPHA-GLYCEROPHOSPHATE DEHYDROGENASE. G. D. Howell†, P. R. Rosevear\*, and J. H. Yuan.\* Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

The properties of the coenzyme binding site of chicken muscle alpha-glycerophosphate dehydrogenase were studied by inhibitor analysis. Four adenosine derivatives, adenosine, AMP, ADP, and ADP-ribose, were found to inhibit the enzyme catalyzed reduction of NAD competitively. The presence of the adenosine region and the pyrophosphate region at the coenzyme binding site of the enzyme was suggested by the inhibitor dissociation constants obtained for these compounds.

Sodium salts of n-alkylphosphate and N<sup>1</sup>-alkylnicotinamide chloride with various alkyl chainlengths were shown to inhibit the enzyme catalyzed reduction of NAD competitively. The chainlength effect was observed in the binding of these compounds to the enzyme, suggesting the presence of a pyridinium ring region and a nearby hydrophobic region at the coenzyme binding site. The involvement of the hydrophobic region in the anticooperative interaction between two coenzyme binding sites of the enzyme dimer was demonstrated by a fluorescence titration of the enzyme with various competitive inhibitors.

A CONTROVERSY IN G. C. DUPLEX STRUCTURE. J. M. Keller\*, R.O. Carter\*, and T.O. Sitz\*, Chem. Sciences Dep't., Old Dominion Univ., Norfolk, Va. 23508.

In previous melt studies on 5.8S rRNA the T<sub>m</sub>'s could only be observed at low ionic strength where the very stable region of the 5.8S rRNA melted at 83°C. It has been concluded that this stable section is the G-C rich region within the sequence of the 5.8S molecule.

The literature provided inconclusive and conflicting experimental data on G-C regions within molecules and poly (G+C) duplexes. The stability model of Borer et al. (J.Mol. Biol., 1974, 86, 843) predicts the T<sub>m</sub> of a G-C duplex like the one found in 5.8S rRNA to be 92°C. However, the existing data (Sitz et al., submitted to Biochemistry) gives a T<sub>m</sub> of 116°C when extrapolated to 1 molar salt. Therefore, indicating the need to develop model systems for predicting the stability of G-C rich regions in native RNA.

A starting point for characterizing the G-C duplexes was to reproduce the melt data presented by Pochon and Michelson (Proc. N.A.S., 1965, 53, 1425). The Michelson paper reports a T<sub>m</sub> of 89°C for poly (G+C) in 80% methanol and 1.5 mM sodium. The data we have compiled thus far indicates a T<sub>m</sub> of 93°C in 80% methanol and salt concentration several orders of magnitude lower. This data indicates that the previously reported T<sub>m</sub> is low.

Studies are now being initiated to study the "melting" process for a series of G-C oligonucleotides whose chain lengths vary.

THE DIMERIZATION OF 5.8S rRNA. S.C. Kuo\* and T.O. Sitz\*, Chem. Sciences Dep't., Old Dominion Univ., Norfolk, Va. 23508, R. N. Nazar\*, Nat. Res. Council, Div. of Biol. Sciences, Ottawa, Canada K1A 0R6.

Kinetic studies and direct chemical evidence suggest that a 8-10S rRNA molecule is a precursor of 5.8S rRNA (FEBS Letters (1975) 57, 26 and FEBS Letters (1976) 61, 10). It has been demonstrated on 2D gels that the second dimension (denaturing conditions) generates two spots from the 10S region, one 10S and the other 5.8S (Biochem. Biophys. Res. Commun. (1974) 56, 1017). This data suggested that the 10S fraction contained 80% 5.8S rRNA dimer and 20% 10S RNA unrelated to 5.8S. The presumed precursor may be the dimer.

The 5.8S rRNA molecule can be isolated and used as a model system to study RNA-RNA intermolecular interactions. When the 5.8S rRNA is heated to 65°C in 0.15M NaCl and allowed to cool, two competing reactions take place; the intramolecular formation of the 5.8S secondary structure and the intermolecular formation of the dimer. If the RNA concentration is above 0.8 mg/ml, over 90% of the monomer 5.8S rRNA is converted to two dimer forms, the major and minor hydrogen bonded dimers.

STUDIES INVOLVING THE ACCURACY OF A PORTABLE WATER ANALYSIS KIT. R. B. Lam\*, J. J. Leary, and F. A. Palocsay, Dept. of Chemistry, Madison College, Harrisonburg, Virginia 22801.

A study was undertaken to evaluate the accuracy of a commercially produced portable water analysis kit (Hach Chemical Company Model DR-EL Direct Reading-Engineers' Laboratory). A representative set of tests available in the kit was selected for study. For each test, an accepted analytical procedure (1) was chosen. "Unknowns" were prepared and analyzed using both the kit and the standard technique. This work indicated that qualitative or semi-quantitative results can be obtained by careful use of the kit.

(1) Taras, M. J., ed., Standard Methods for the Examination of Water and Wastewater, 13th edition (Washington, D. C.: American Public Health Association, 1971).

CONSTITUENTS OF FOMES ROBINIAE. Sarah P. Lawrence\* and James B. Patrick, Mary Baldwin Coll., Staunton, Va. 24401

Fomes robiniae (Murr.) Sacc. et D. Sacc. (Polyporaceae) is a woody bracket fungus which is abundant in the central Shenandoah Valley. While investigating the chemical constituents of this fungus we have obtained an orange-brown pigment, a brilliantly fluorescent component, and a non-polar oil.

The oil was characterized by mass spectrometry, gas chromatography, infrared spectroscopy, and proton and carbon nmr spectrometry as bis-(2-ethylhexyl)phthalate. Contamination by such obvious sources as Tygon tubing was systematically excluded as the origin of the phthalate.

Bis-(2-ethylhexyl)phthalate has been previously reported as a fungal metabolite in three separate instances. We now report studies designed to settle whether bis-(2-ethylhexyl)phthalate can be an endogenous metabolite of F. robiniae, as well as preliminary characterization of the other isolated compounds.

THE PURIFICATION AND STABILITY OF A SINGLE STRAND SPECIFIC NUCLEASE (S<sub>1</sub>) FROM ASPERGILLUS ORYZAE. K. S. Liu\*, R.O. Carter\*, and T.O. Sitz\*, Chem. Sciences Dep't. Old Dominion Univ., Norfolk, Va. 23508.

The purification procedure for S<sub>1</sub> nuclease developed by Vogt (Eur. J. Biochem. (1973) 33, 192) has been modified to improve the total amount of activity obtained. When the G-100 Sephadex column, the last step in the procedure developed by Vogt, was used there was a 90% loss of enzyme activity. This is similar to the loss reported by Sutton (Biochem. Biophys. Acta (1971) 240, 522) when G-75 Sephadex was used. When fractions from the G-100 Sephadex column were incubated with mercaptoethanol (1mM) there was a fifteen fold stimulation in enzyme activity. It would appear that the enzyme has a sulfhydryl group necessary for activity. The Sephadex procedure stimulates the oxidation of this group but the addition of a sulfhydryl protector like mercaptoethanol will prevent this inactivation or reverse it. The use of mercaptoethanol has allowed a 300 fold purification of the enzyme.

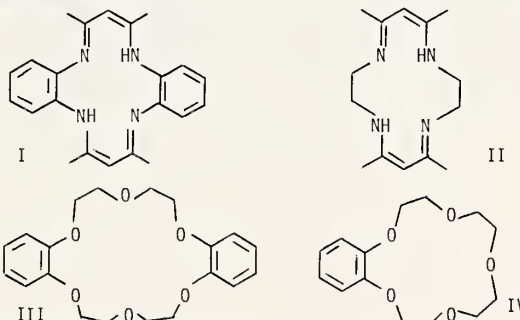
Vogt has reported a 3,000 fold purification of S<sub>1</sub> nuclease which was not reproducible in our laboratory. Other procedures are being investigated to improve the yield and purity of the enzyme. One of the most encouraging techniques is affinity column chromatography using ATP covalently attached to Sepharose. Preliminary studies have demonstrated a high affinity for this ligand making it useful in purifying S<sub>1</sub> nuclease.

THE KINETICS OF THE REACTIONS OF CERTAIN AMINOFLUORENONES WITH PHTHALIC ANHYDRIDE. J. G. Mason and E. Sugg, Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The kinetics of the reactions of 2-amino-, 2,5-diamino-, 2,6-diamino-, and 2,7-diamino fluorenone with phthalic anhydride have been measured spectrophotometrically in dimethylacetamide. For the diamino fluorenones the rate of the formation of the monoamic acid was measured and found to be correlatable with basicity. For the 2,7-diamino fluorenone, rate constants for the formation of both the mono- and bis-amic acids were obtained.

SCANDIUM(III) COMPLEXES WITH SOME NEUTRAL MACROCYCLIC LIGANDS. Gordon A. Melson and Dennis J. Olszanski\*, Dept. of Chemistry, Virginia Commonwealth University, Richmond, VA 23284.

Complexes of the scandium(III) ion with the macrocyclic ligands Me<sub>4</sub>Bz<sub>2</sub>[14]tetraeneN<sub>4</sub>, I; Me<sub>4</sub>[14]tetraeneN<sub>4</sub>, II; dibenzo-18-crown-6, III; and benzo-15-crown-5, IV, have been synthesized and characterized by a variety of physical measurements.



These complexes are the first examples of scandium(III) complexes with "synthetic" macrocyclic ligands.



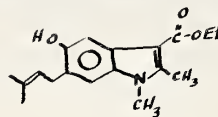
THE JAHN-TELLER EFFECT IN COPPER. THE RELATIONSHIP BETWEEN THE CRYSTAL AND ELECTRONIC STRUCTURES OF  $\text{Cu}(\text{C}_6\text{H}_5\text{NO})_2(\text{ClO}_4)_2$  AND RELATED COMPLEXES. C.J. O'Connor\*, R.L. Carlin\* and E. Sinn. Dept. of Chemistry, Univ. of Va, Charlottesville, VA 22901.

Hexakis (pyridine N-oxide)copper(II) perchlorate and the isomorphous zinc analog crystallize in the trigonal space group  $R\bar{3}$ . The  $\text{Cu(II)} d^9$  electronic ground state is doubly degenerate in fields of trigonal symmetry. The energy level is split by a Jahn-Teller distortion to rhombic symmetry. This phenomenon is observed in the room temperature EPR spectrum of the zinc compound doped with ~0.5% copper ion impurity, but not in the crystal structure. Thus we have a dynamic Jahn-Teller distortion with an interconversion rate slow enough to allow observation of the individual components in the ESR spectrum. The bulk magnetic susceptibilities (1.5-20K) agree with the trigonal crystallographic predictions and the specific heat measurements (2-12K) indicate the presence of magnetic interactions at lower temperatures.

ISOPRENOID INDOLOQUINONES: A SYNTHETIC STUDY. James B. Patrick and Sarah Elizabeth Campbell\*, Mary Baldwin Coll., Staunton, Va. 24401.

6-Prenylindoloquinones are of interest as novel structures which may combine the pharmacological properties of lapachol and of the mitomycin antibiotics. We have devised a synthetic sequence that leads from the known prenylbenzoquinone via the hydroxyindole I, prepared by the Nenitzescu indole synthesis. Several useful synthetic modifications on the way to I are described.

Oxidation of I by Fremy's Salt, the usual entry into the indoloquinone series from a 5-hydroxyindole, is entirely ineffective under a variety of conditions. An alternative method is described. The geranyl analogue of I has also been made. The instability of cinnamylbenzoquinone has so far precluded the preparation of the cinnamyl hydroxyindole.



I

(Work supported by a Cottrell College Science Grant from Research Corporation)

A LABORATORY EXPERIMENT USING THE EDMAN DEGRADATION AND GAS-LIQUID CHROMATOGRAPHY. K. P. Potter\*, J. J. Leary, and W. H. Voige, Dept. of Chemistry, Madison College, Harrisonburg, Virginia 22801.

A laboratory experiment which employs the Edman degradation and gas-liquid chromatography for the determination of the amino acid sequence of a dipeptide has been developed. The experiment is appropriate for junior/senior level analytical chemistry and biochemistry laboratories.

Phenylisothiocyanate (PITC) is reacted with a dipeptide. The peptide bond of the derivatized dipeptide is cleaved to yield the phenylthiohydantoin (PTH) derivative of the amino-terminal amino acid and the underivatized carbonyl-terminal amino acid. The PTH-amino acid is separated from the underivatized carbonyl-terminal amino acid by extraction. The latter amino acid is reacted with PITC to yield its PTH-derivative. The PTH-derivatives are identified by gas-liquid chromatography.

HOW MICROORGANISMS HELP US STUDY DRUG DEACTIVATION PROCESSES. O. R. Rodig, Dept. of Chemistry, Univ. of Virginia, Charlottesville, VA 22901

Drugs can be deactivated by reactions catalyzed by a number of enzymes which are found in various body organs. After a brief survey of drug metabolism, the discussion will center on how we have been able to utilize enzymes found in microorganisms in elucidating the organic chemistry occurring in some drug deactivation processes, with particular emphasis on drugs of the steroid hormone, sex hormone, and contraceptive types.

DIFFERENTIAL PULSE POLAROGRAPHIC STUDY OF SOME SUBSTITUTED DIPYRIDYL COMPOUNDS. R. T. Salmon\* and F. M. Hawkrige. Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23298

Investigations of several dipyridyl compounds; 1,1'-trimethylene-5,5'-dimethyl-2,2'-dipyridinium dibromide; 4,4'-dimethyl-1,1'-trimethylene-2,2'-dipyridyl dibromide; and 4,4'-diphenyl-1,1'-trimethylene-2,2'-dipyridyl ditro-mide have been undertaken in order to determine their suitability as mediator-titrants in the coulometric titration of the primary electron acceptor of photosystem I.  $E^\circ$  values determined by differential pulse polarography will be presented. And the results of cyclic voltametry at a hanging drop mercury electrode will be presented.

THE REDOX STATE OF LUNAR AND TERRESTRIAL MAGMAS: MODELS FROM STUDIES OF OXIDATION-REDUCTION EQUILIBRIA OF TRACE METALS IN SYNTHETIC SILICATE LIQUIDS. Henry D. Schreiber, Dept. of Chemistry, Va. Military Inst., Lexington, Va. 24450

The oxidation-reduction equilibria of  $\text{Ti(IV)-Ti(III)}$ ,  $\text{Cr(VI)-Cr(III)-Cr(II)}$ ,  $\text{Eu(III)-Eu(II)}$  and  $\text{Zr(IV)-Zr(III)}$  were investigated in synthetic Ca-Mg-Al-silicate melts as a function of the bulk melt composition, temperature and oxygen fugacity. Analytical measurements provided the concentrations of the oxidized and the reduced valence states of the Ti, Cr, Eu and Zr redox couples in the corresponding quenched glasses from the melts.

Insofar as these synthetic silicate melts represent magmas (e.g. volcanic lavas), predictions of the redox state of lunar and terrestrial magmas are obtained from the experimental studies using simulated lunar and terrestrial environments. Whereas terrestrial magmas contain Ti, Cr, Eu and Zr as  $\text{Ti(IV)}$ ,  $\text{Cr(III)}$ ,  $\text{Eu(III)}$  and  $\text{Zr(IV)}$  exclusively, the reducing conditions on the Moon stabilized significant amounts of  $\text{Ti(III)}$ ,  $\text{Cr(II)}$  and  $\text{Eu(II)}$ , but not  $\text{Zr(III)}$ , in lunar magmas. The redox state of the primary magma affects the chemistry and stability of the subsequent mineral phases which crystallize from the melt, as well as influences the elemental distribution patterns among these minerals.

AN EVALUATION OF TWO COMPUTER SHORT COURSES FOR COLLEGE TEACHERS - SUMMER 1976. F. A. Settle, Jr., P. B. Peters and G. C. Balazs, Virginia Military Institute, Lexington VA 24450

Two summer short courses for junior and community college teachers of math, science and technology, sponsored by U.S. Office of Education, were offered at VMI during the summer of 1976. The first one week course began with elementary digital electronics and terminated with micro-processor applications. The second two week course dealt with software applications of high level programming languages to the respective disciplines of the participants (25% chemists). A significant amount of time in both courses was devoted to giving participants hands-on experience.

The format, resource material and equipment used in both courses will be presented. Results particularly applicable to chemistry curricula will be discussed.

Discussion groups revealed a number of problems with computer usage at participant's institutions. These included lack of facilities, uncooperative computer center personnel, lack of interest by peers, etc. The results of these discussions will be summarized.

A STUDY OF THE DYNAMICS OF A MONTECARLO LATTICE BEAD POLYMER AS A FUNCTION OF CONCENTRATION. B. Shardt\* and D. Kranbuehl, Dept. of Chemistry, College of William and Mary, Williamsburg, Va. 23185

A Monte Carlo lattice bead model of a polymer chain is used to stimulate the dynamic properties of polymer chains in solution. The autocorrelation function of the vector end-to-end length and the translational diffusion constant are used to characterize the dynamic properties of the chain as a function of polymer concentration. It was found that the ratio  $D_e \tau_e / \langle l^2 \rangle$  remains constant, and is independent of chain length and the polymer concentration.

MAGNETIC INTERACTIONS BETWEEN PAIRS OF METAL ATOMS IN COMPLEXES OF COPPER(II) WITH ORGANIC LIGANDS. THE CHANGE-OVER POINT BETWEEN FERROMAGNETISM AND ANTIFERROMAGNETISM. P.G. Sim\* and E. Sinn. Dept. of Chemistry, Univ. of Va., Charlottesville, Va 22901.

Schiff base complexes of copper(II) form binuclear complexes with a variety of compounds such as copper halides,  $\beta$ -diketonates and, in some cases, themselves. In such cases, the binuclear complexes contain ligand-bridged metal atoms which generally exhibit ferromagnetic or antiferromagnetic interactions. We have used X-ray crystallography to determine the molecular structure, and high precision magnetic susceptibility measurements to determine the electronic structures of a series of complexes. Comparison of the electronic and molecular structures show how small changes in the molecular structure affect the tendency to pair unpaired electrons and vice versa.

STRUCTURAL EFFECTS OF ELECTRON PAIRING IN TRANSITION METAL COMPLEXES. PHENOMENA OF PHYSICAL AND BIOLOGICAL INTEREST. E. Sinn, Dept. of Chemistry, Univ. of Va., Charlottesville, Va. 22901

In a series of ferric dithiocarbamates, and the iron(III) complexes of the ligands formed by condensation of triethylenediamine with  $\beta$ -diketones or related compounds, an equilibrium is observed between high spin and low spin species, which involves the pairing or unpairing of two electrons per molecule. The equilibrium can be affected by a number of factors such as temperature, pressure or slight chemical modification of the ligands. The inclusion of neutral solvent molecules into the lattice also has a dramatic effect, frequently greater than that obtained from a pressure change of several thousand atmospheres, or temperature change of several hundred degrees.

The results of a variety of physical measurements indicate an average metal-ligand bond length change of 0.13Å for the electron pairing involved in the equilibrium, and that this observation is general, rather than limited to the specific model complexes used here.

ELECTRON SPIN RESONANCE STUDIES OF  $\beta$ -TRIMETHYLSILYLSTYRENE RADICAL ANION. H.J. Sipe, Jr., A.F. Gall\*, P.M. Bayliss\*, and G.K. Bumgardner\*, Department of Chemistry, Hampden-Sydney College, Hampden-Sydney, Virginia 23943

The title compound,  $\text{PhCH}=\text{CHSiMe}_3$ , is synthesized by coupling the Grignard reagent of  $\beta$ -bromostyrene with trimethylchlorosilane. NMR evidence indicates that only trans product forms even though mixed isomers of  $\beta$ -bromostyrene are employed. Radical anions of the title compound form readily when it contacts Na/K mirror in ethereal solutions at  $-95^\circ\text{C}$ . Well-resolved but complex esr spectra are observed for the radical anion and may be rationalized by comparison with esr results for the related radical anions of 1,2-bis(trimethylsilyl)ethylene, trans-stilbene, and styrene itself. Hückel molecular orbital calculations that treat the trimethylsilyl-substituent as a pseudo-heteroatom and that employ parameters established in previous esr investigations are moderately successful in predicting the esr hyperfine coupling constants of the title compound. Verification of coupling constant assignments by esr studies of methyl-substituted analogs of the title compound is presently underway.

HETEROGENEOUS OXIDATION AND REDUCTION OF SPERM WHALE MYOGLOBIN USING SURFACE MODIFIED GOLD ELECTRODES. Joyce F. Stargardt\*, and Fred M. Hawkridge. Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

Sperm whale myoglobin has been heterogeneously oxidized and reduced by applying appropriate potentials to an optically transparent thin layer electrochemical (OTTE) cell. The working electrode of the (OTTE) cell consists of a gold minigrid which has been modified with benzyl viologen (1,1'-dibenzyl-4,4'-dipyridyl dichloride) which exhibits quasi-reversible rates of electron transfer with myoglobin.

In scanning electron micrographs of the modified electrode the benzyl viologen appears to be of a polymeric form.

The possible clinical analysis of heme proteins by direct optically coupled electrochemical methods is being further investigated in our laboratories.



LITHIUM-7 NUCLEAR MAGNETIC RESONANCE AS A PROBE OF STRUCTURE AND FUNCTION OF THE MONOVALENT CATION SITE ON PYRUVATE KINASE. E.M. Stephens\* and C.M. Grisham\*, Dept. of Chemistry, Univ. of Va., Charlottesville, Va. 22901

Nuclear relaxation and kinetic studies indicate that lithium-7 can be an effective probe of monovalent cation-binding sites of enzymes.  $K^+$  is the normal activator of rabbit muscle pyruvate kinase, but  $Li^+$  activates weakly with an apparent  $K_m = 11 \text{ mM}$  which is relatively insensitive to the concentration of other substrates. Moreover, we have found that the  $Li$ -7 NMR resonance can be easily observed using a standard carbon probe at 25 MHz. This requires dropping the field to 15.2 KG and precludes use of field/frequency locking. However, we have obtained signal/noise  $>10$  under all conditions using 50 mM  $LiCl$  and a single transient.

The longitudinal relaxation rate,  $1/T_1$ , of  $Li$ -7 in solutions of pyruvate kinase increases linearly with added  $Mn^{2+}$  until the enzyme is saturated with  $Mn^{2+}$ . Larger effects are seen in the presence of phosphoenolpyruvate. No increase in  $1/T_1$  is seen in the absence of enzyme or when  $Mg^{2+}$  is added instead of  $Mn^{2+}$ . Using the  $1/T_1$  data  $Li^+$  to  $Mn^{2+}$  distances of 11.0 Å and 5.8 Å are calculated in the absence and presence of phosphoenolpyruvate, respectively. These values are greater than the corresponding  $Tl^+$  to  $Mn^{2+}$  distances of 4.9 Å and 8.2 Å found for this enzyme (J. Reuben and F. Kayne, J. Biol. Chem. 246, 6227). The significance of these greater distances is discussed in relation to the relative effectiveness of  $Tl^+$  and  $Li^+$  as activators of the enzyme.

PURIFICATION AND CHARACTERIZATION OF THE CO-ENZYME BINDING SITE OF MOUSE TESTES LACTATE DEHYDROGENASE-X. J. L. Topping\* and J. H. Yuan\*. Dep't. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Lactate dehydrogenase-X (LDH-X) from mouse testes has been purified to homogeneity by an 8-(6-aminohexyl)-amino-AMP-Sepharose affinity chromatography. Studies of the coenzyme-binding site of the purified enzyme were performed by inhibitor analysis. Adenosine, AMP, ADP, and ADP-ribose were shown to be coenzyme-competitive inhibitors of LDH-X. The effectiveness of the binding of these compounds to the enzyme increased with the size of the adenosine derivatives employed. Multiple inhibition analysis suggested that these compounds are interacting with the same regions of the coenzyme-binding site as with the mutual exclusion of one another from binding to the enzyme.

Sodium salts of n-alkylphosphate with various alkyl chain-lengths were shown to inhibit the enzyme-catalyzed reduction of NAD noncompetitively. However, the inhibition of LDH-X by n-alkylphosphate in the presence of 0.33 mM AMP was found to be competitive with respect to NAD. The results of these studies suggested that the binding of coenzyme to LDH-X occurs through interactions involving the adenosine moiety and pyrophosphate grouping.

DETERMINATION OF TRACE AMOUNTS OF PENTACHLOROPHENOL BY DIFFERENTIAL PULSE POLAROGRAPHY. A. L. Wade\* and F. M. Hawkridge, Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, Va. 23284

Pentachlorophenol (PCP) concentrations have been determined at sub-ppm levels by differential pulse polarography (DPP). This compound undergoes reduction at a mercury electrode and the resulting peak can be used for both qualitative and quantitative analysis. Quantitative measurements were made by standard addition in buffer solutions of pH 7 - 11, and the peak heights were found to be linear for concentrations down to 0.3 ppm. The summit and half-wave potentials ( $E_s = -0.800 \text{ V}$  and  $E_{1/2} = -0.720 \text{ V}$  versus  $Ag/AgCl$ ) were independent of pH over this range, indicating that hydrogen ions are not involved in the rate-determining step. Cyclic voltammetry at a hanging mercury drop electrode was used to characterize the reversibility of this electrochemical reaction.

This electrochemical procedure for PCP is rapid and direct compared with gas chromatographic or spectrophotometric procedures in current use that require derivatives. Although this method is not as sensitive as the more complicated gas chromatographic methods, the results obtained indicate that screening using DPP is reasonable.

STEREOCHEMISTRY OF SOME PHOTOCYCLIZATION REACTIONS Richard J. Sundberg, Richard L. Parton, P.C. Srinivasan, Stuart Schreiber, and Javier Guiterrez, Dept. of Chemistry, Univ. of Va., Charlottesville, Virginia, 22901.

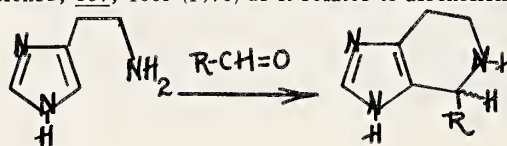
A satisfactory synthesis of 2-indolyl 3-pyridylmethyl ketones has been developed. These intermediates have been converted to substrates which are suitable for study of chloroacetamide photocyclization. Photocyclization provides the quebrachamine skeleton in yields of about 40%. NMR studies show that the dominant product is related to the more stable ground state conformation of the starting material. The stereochemical relationship between the photoproduct and the more stable compounds derived by thermal equilibration will be discussed.

DEGRADATION OF POLYIMIDE PRECURSOR RESINS. G. Tsahakis\* and D. Kranbuehl, Dept. of Chemistry, College of William and Mary, Williamsburg, Va. 23185

The stability of a series of BTDA-DABP and BTDA-MDA, polyimide precursor resins in DMAC was investigated by measuring the number average molecular weight as a function of time. The molecular weight measurements were made using a membrane osmometer. The dependence of the rate of degradation on the chemical nature of the diamine and the geometric structure about the amide linkage was examined and discussed in terms of a previously proposed mechanism for degradation. The effect of the presence of water, the concentration of the resin, and the temperature was also investigated. The degradation rate was doubled by the addition of 0.5(v/v)%  $H_2O$  to the anhydrous resin solution. Increasing the concentration of the resin solution and the presence of an electron donating group between the phthalic acid groups increased the stability.

SYNTHESIS AND PROPERTIES OF THE 4,5,6,7-TETRA-HYDRO-3H-IMIDAZO(4,5-c)PYRIDINE RING SYSTEM. R. L. Williams and Gretchen Williams\*. Dep't. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. and Dep't. of Pharmacology, Eastern Virginia Medical School, Norfolk, Va. 23508.

Histamine and histidine have been condensed with a variety of aliphatic and aromatic aldehydes under typical Pictet-Spengler conditions to give rise to some rather interesting tetrahydroimidazopyridines. The general reaction mechanisms will be discussed together with the pertinent physical and spectral properties of these compounds. The condensation products of histamine with formaldehyde and acetaldehyde will be considered further in regard to the current aldehyde metabolite theory. (V. Davis et al, Science, 167, 1005 (1970) as it relates to alcoholism.





A POLYNOMIAL "BEST-FIT" PROGRAM IN BASIC. John H. Wise, Dept. of Chemistry, Washington and Lee Univ., Lexington, Va. 24450.

Several programs in the BASIC language have been prepared in conjunction with a course on data handling and statistical procedures. One of these is a least squares polynomial curve fitting program adapted to BASIC from Dickson's text\*. This program has been further modified to a "best-fit" solution by including a loop to search for the polynomial order which gives a minimum sum of squared residuals within some arbitrary tolerance. In operation, the sum of squared residuals for each step in the loop is output, and the final output gives the polynomial coefficients and a table of x, y, y (calc.), and residual.

Other programs in the data handling group will be mentioned briefly.

\*Dickson, T.R. "The Computer and Chemistry", W.H. Freeman and Company, San Francisco, Calif., 1968.

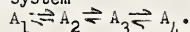
PURIFICATION OF BULL SEMEN NICOTINAMIDE ADENINE DINUCLEOTIDE GLYCOHYDROLASE BY AFFINITY CHROMATOGRAPHY. D. L. Wolan\* and J. H. Yuan\*. Dep't. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

NAD glycohydrolase (NADase), capable of catalyzing the hydrolysis of the nicotinamide N-ribosidic linkage of NAD, was purified previously by conventional procedure (J. Biol. chem., 246:2111, 1971). A simple, rapid method for the purification of NADase from bovine seminal plasma by an affinity chromatography procedure has been developed.

In studies of the properties of the substrate binding site of the enzyme, it was demonstrated that compounds structurally analogous to different portion of the NAD molecule were effective substrate-competitive inhibitors of this enzyme. N<sup>1</sup>-methylpyridinium chlorides, although containing a variety of functional groups substituted on the pyridinium ring, were found to inhibit the NADase-catalyzed reaction. Varying the substituent group on the pyridinium ring altered significantly the binding properties of these inhibitors. Interactions of these inhibitors with the pyridinium ring regions of the substrate binding site was suggested by the competitive nature of the inhibition and the observation of simultaneous binding of these inhibitors with adenosine derivatives in the multiple inhibition analysis.

AN AUDIO TAPE-ANALOG COMPUTER TEACHING PROGRAM FOR CHEMICAL KINETICS. J. E. Worsham, Jr., Department of Chemistry, University of Richmond, Va. 23173

An analog computer was programmed to solve the system of simultaneous differential equations that describe the kinetics of the system



The solution is carried out for both the usual case of specifying  $A_1^0$  and the very interesting case not usually treated of  $A_1$  being added to the system at a constant rate,  $F_1$ , and the system achieving a steady state. An audio tape was prepared giving students the directions for operating the system and for making pertinent observations. On a report form furnished by the instructor, students sketched families of curves for various sets of parameter values, answered leading questions designed to signal important points and made pertinent calculations from textbook equations to compare with single points on the curves of the analog computer.

A GENERAL PURPOSE SYSTEM OF COMPUTER PROGRAMS FOR QUIZZES AND DRILLS. J. E. Worsham, Jr., Dept. of Chemistry, University of Richmond, Va. 23173

An integrated system of computer programs in BASIC for the HP-2000C computer used by the University of Richmond has been written to allow instructors to conveniently enter and edit quizzes or drills which students can take at remote computer terminals operating interactively in a time-sharing mode. The items are necessarily objective, one or two word completion questions or multiple choice questions. The program system permits up to 5 equivalent correct answers for each question. Responses to the student's answers are chosen randomly from an appropriate file which considerably reduces the mechanical nature that can be a drawback in such systems as this.

The system can be used for programmed learning as well as for quiz and drill. One program designed to teach the use of the mole method for simple weight-weight problems has been successfully implemented.

An important feature of the system is the storage of the students' performance record on each quiz which is the student's name, the day and hour he took a given quiz, the number of wrong responses to each question and his score. The system is quite general and can be used for any subject matter.

SYNTHESIS AND PROPERTIES OF 2- AND 6-AMINONICOTINE. J. Mark Yi\*, Jeffrey S. McKennis\*, Edward R. Bowman, and Herbert McKennis, Jr., Div. of Biochemical Pharmacology, Med. Col. of Va., Richmond, Va., 23298, and Dept. of Chemistry, Okla. State Univ., Stillwater, Okla., 74074.

Tschitschibabin and Kirssanov described (1924) the amination of natural nicotine with sodium amide to obtain two racemic products, 2-aminonicotine (I) and 6-aminonicotine (II), in yields ranging from good to poor. Interest in the biological activity of the aminonicotines, (Mednikyan, 1936) and their employment after coupling (Langone et al., 1973; Haines et al., 1974; Matsukura et al., 1975; Castro & Prieto, 1975) with macromolecules in the production of antisera for the radioimmunoassay of nicotine has led to a re-investigation of the Tschitschibabin reaction. I (m.p. 126°), purified by recrystallization or sublimation, was converted to 2-(p-nitrobenzamido)nicotine (III, m.p. 217°). Hydrogenation of III in the presence of Raney nickel afforded the readily diazotizable 2-(p-aminobenzamido)nicotine (IV), which was coupled with bovine serum albumin to provide an antigen (V) (approximately 28 moles of 2-aminonicotine/mole of BSA-by hydrolysis). V provides nicotine antisera of high titer (A. Castro, private communication). The permanganate oxidation of benzoylated 2-aminonicotine provides products which support the original structural assignment of Tschitschibabin and that of Gol'dfarb and Godovikova (1961).

(Aided by grants from the Council for Tobacco Research-U.S.A., Inc. and The American Tobacco Company)

SOURCES FOR COURSEWARE IN CHEMISTRY, G. E. Copeland, Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

During the evolution of the NSF-ODU CAUSE Project the Computer Based Learning Laboratory has identified the major sources for computer courseware in all disciplines. The major sources are Index to Computer Based Learning, Anastasia Wang, (1976) University of Wisconsin-Milwaukee and Project CONDUIT at the University of Iowa. Together these two sources have over 200 separate computer programs in all fields of chemistry which are transportable to most medium size systems. Many computer enriched modules in introductory chemistry have been assembled by a NSF-E Exxon funded grant under Dr. Harold Weinstock at ITT, Chicago and will run on mini-computers. An excellent review of these activities is provided by Peter Lykos' The Computer Role in Undergraduate Chemistry Curriculum, UNESCO (1976). A major source for CAI, computer assisted test construction and a library of simulative and data reduction programs is Dr. K. Jeffrey Johnson at the University of Pittsburgh. Also of the 490 programs in the North Carolina Educational Computing Service (NCECS) over one third are in chemistry!



# Symposium on Computer Science

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

PROPERTIES OF EXTENDED LOCALITY INTERVALS. A. P. Batson\* and J. P. Kearns\*. University of Virginia, Charlottesville

The concept of bounded locality intervals [Madison and Batson, "Characteristics of Program Localities," CACM, Vol. 19 (5), 1976, pp. 285-294] has been extended to include that period during which the BLI's set of segments is being formed at the top of the LRU stack. We may then distinguish three sub-phases within the extended BLI, each sub-phase yielding distinctive patterns of reference behavior. These sub-phases are

- (1) the head, during which the locality is formed,
- (2) the body, characterized by repeated references to all of the locality's constituent segments, and
- (3) the tail, the sub-phase immediately preceeding termination of the locality.

Empirical data from a sample of production ALGOL 60 programs are used to characterize sub-phase size and lifetime. The results are discussed with respect to their implications for the modeling of program behavior and memory management in virtual memory systems. [This work supported in part by NSF Grant GJ-1005].

PRACTICAL CONSIDERATIONS INVOLVING OCEANIC DATA BASES.

Gerald L. Engel, Dept. of Computing & Statistics, Virginia Institute of Marine Science, Gloucester Pt., Virginia 23062

While data base systems for oceanic research may be easily identified and defined, the key issue in the successful implementation of such a system is the interaction and assignment of responsibilities to the participants in the projects generating the data and the end users of the data systems. Areas of concern on these issues will be addressed.

In addition to problems that are internal to a particular institution developing a data system there exists the more primary issue of the interaction of various systems that already exist. While there is concern with the entry of data into a national archive, there is little concern with the integrity of data. While there is concern with collection of data, there is little concern with the statistical validity of collection mechanisms. Instead of questioning intercomparability of data, we concern ourselves all too often with only form.

It must further be recognized that the eventual end user of data systems will require information that combines hard data with the literature. It must also be realized that what we are doing is not going to necessarily lead to scientific based decisions, but rather may be directed to rationalizing political decisions. If we are to have input to the decision maker it is essential that our data system supply quickly and efficiently that information that is required to cause as little damage as possible.

A COMPUTER BASED STATE ENVIRONMENTAL INFORMATION SYSTEM. R. H. Giles, Jr. Dept. of Fisheries and Wildlife Sciences and Div. of Environmental and Urban Systems, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A multi-level data base for Virginia is described. Planning districts, watersheds, counties, and cellular data are stored. There are 1.1 million cells in the state, each  $1/9 \text{ km}^2$  or 27 acres. Each contain about 100 environmental, spatial, land use, and human factors. High-elevation satellite inputs are being explored.

Examples are presented of use of the system in locating power lines and in generating maps reflecting integrated factors such as solar incidence and viewscapes. Potentials for use of the system in biogeography, land use, environmental health, and wildland management are explored.

The author's interactive uses of the system in impact assessment, creating Dynaplan, and in developing prescriptions for strip mine reclamation and wildland optimization are described.

SOME PARALLEL MATRIX ALGORITHMS. Frances L. Van Scoy, Dept. of Mathematical and Computing Sciences, Old Dominion University, Norfolk, Virginia 23508.

Parallel algorithms on  $n \times n$  matrices are described for an  $n \times n$  array of processors. Multiplication and transposition algorithms requiring time  $kn$  and an inversion algorithm requiring at most time  $kn^2$  are presented. These times compare with times of  $kn^{\log_2 7}$ ,  $kn^2$ , and  $kn^{\log_2 7}$  for the best known sequential algorithms. A transitive closure algorithm requiring time  $kn$  and allowing the recognition of the adjacency matrix of a tree is also given. This is an improvement over the best known sequential algorithm which requires time between  $kn^2$  and  $kn^3$ .

(Based on work done for the author's Ph.D. thesis at the University of Virginia.)

A DESCRIPTION OF THE VIMS HYDRO DATA BASE SYSTEM. Ginny Shaw, VIMS, Gloucester Pt., Va. 23062

The VIMS Hydro Data Base System is a multipurpose storage and retrieval system implemented on the IBM 70/115 housed at VIMS. Its purpose is to provide storage and retrieval of hydrographic data related to Chesapeake Bay and its estuarine tributaries. Present storage includes over 70,000 records spanning the years 1942-1975. Data is entered and retrieved by batch processing methods. It is stored on a direct access device which allows retrieval according to selected criteria, i.e. river code, latitude and longitude, date, type of data recorded, etc.

The system is useful for both scientific research and marine resources management. Mathematical models of estuaries, prepared at VIMS, are easily verified using the system. Historical background (baseline data) is available for research planning and for the scientist attempting to evaluate problems and changes in the marine environment. Other agencies involved in management and planning activities frequently require baseline data in their decision-making processes.

The design and implementation of the Hydro system will be discussed in this paper.

AN IMPLEMENTATION OF A DATA REDUNDANCY REDUCTION ALGORITHM USING MICROPROCESSORS. Murali Varanasi and David Livingston. Dept. of Electrical Engineering, Old Dominion University, Norfolk, Virginia 23508

Many data acquisition systems operate at sampling rates which are higher than necessary. Such oversampling results in redundant data which takes up valuable memory space and processing time. One possible solution to this problem is preprocessing by compressing the amount of data with respect to its information trend. With the advent of the microprocessor, data compression algorithms are more easily realized using the software capabilities of the microprocessor. One redundancy reduction method which lends itself to a feasible implementation on a microprocessor is the linear predictor. Predictions are based on linear combinations of past data samples with the number of past samples required being one more than the order of the predictor equation.

A computer simulation of an 8080 microprocessor implementation of a zero and first order predictor is presented. Data within the simulation is compressed and encoded in a format which permits easy reconstruction. As an example of the application of this method, processed Viking picture data is also presented. Plans for the future entail possible implementation of higher order predictors and a hardware realization leading to an adaptive compressor system.

## Section of Education

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

LET'S PUT PHYSICS IN ITS PLACE. Frank Akers and Leslie Watkins. Science Department, Glenvar High School, Salem, Va. 24153

High school physics is being taught to some students at the tenth grade level. Students taking algebra in grade nine are invited to participate in this sequence on the recommendation of their math and science teachers. Physics is followed by chemistry at grade eleven and then biology at grade twelve.

Enrollment in physics has increased dramatically, while biology enrollment has not suffered. Students seem to be better prepared for chemistry and biology, and also seem to enjoy the courses more. Those students who take biology in grade ten may still take physics as seniors.

COASTAL ZONE AWARENESS THROUGH COMPREHENSIVE IN-SERVICE EDUCATION. R. Wesley Batten, Director, Mathematics and Science Center, Glen Allen, VA 23060

Approximately 100 teachers were participants in a comprehensive in-service program especially developed to make them more aware of Virginia's coastal zone and its importance. This non-college certificate renewal course offered by the Mathematics and Science Center in Richmond focused upon the Coastal/Oceanic Awareness Studies (COAST) marine education curriculum developed at the University of Delaware.

The classroom application of selected COAST curriculum units and the acquainting of teachers with coastal resources was provided through lectures, class activities, and coastal field trips. Cooperation from the Virginia Department of Education, the Virginia Institute of Marine Science, and the University of Delaware enabled the instructors to present the participants with an overall view of coastal physiography, history, economics, culture and resources.



THE USE OF STUDENT ATTITUDES AS A SOURCE OF FEEDBACK FOR MODIFYING A PRESERVICE ELEMENTARY SCIENCE METHODS COURSE, W. R. Brown. Science Education Ctr., Old Dominion Univ., Norfolk, Va., 23508

The purpose of this two-year study was to use student attitudes as a source of feedback for modifying the open-laboratory component of a preservice elementary science methods course. The emphasis of the open laboratory component was the process orientation to science. Attitudinal questions dealt with seven parameters. Total time per student to complete an activity was also recorded.

Time data were used to modify four activities. The grand mean times were within the time frame set by the investigator.

Generally students ( $n = 120$ ) characterized the series of activities as: interesting, informative, of a medium difficulty level, presented in a likable format, well coordinated in a sequential manner, used materials and equipment appropriate for meeting stated objectives, and did not require extensive instructor assistance.

MAN AND HIS PHYSICAL ENVIRONMENT--AN EXPERIMENT IN UNDERGRADUATE INSTRUCTION. KULDIP P. CHOPRA and LEWIS W. WEBB, JR., Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA 23508.

An introductory course which relates the laws of classical and modern physics to our physical environment, and considers the impact of these relationships on our health and physical well being. The course is concerned with matter, waves, radiation, heat balance of the human body, radioactivity, and the earth's atmosphere, weather and climatology. Additional applications covered in the course include air, water, and noise pollution, methods of energy conversion, transportation, and land use considerations.

Lectures and laboratories are well coordinated; only one to two weeks apart. The subject matter is handled with simple arithmetical and logarithmic calculations.

Except for the hurdles placed by the traditional freshman physics instructors and negligible fiscal support from the department, the supportive response from students completing the two-semester course and the general and specific interests expressed by other departments made this exercise in curriculum innovation a very rewarding experience.

SOUND--QUESTIONS CHILDREN ASK. D.J. DONIEL\*, and E.M. Hairfield, Mary Baldwin College, Staunton, Va. 24401

Sound, a form of energy, can be utilized most effectively in the education of children. Many experiments have been created through which children can gain ideas as to the cause of sounds.

This presentation contains questions that most children ask concerned with how we hear sounds and how sounds are produced. Each question is answered with explanations, experiments, and activities that the children can do to discover answers for themselves. The experiments and activities stimulate thinking, observations, and discussion about the sounds surrounding the children's environment.

Music is an important part of sound. Experiments concerning music create a curiosity as to how music is different from noise and how music is produced.

The goal of these activities is to develop an awareness of the student's environment. The experiments and activities are designed to be set up at all times so that students can further answer their questions through constant experiences. Sample experiments and activities will be presented.

AN UPDATE ON THE PROGRESS OF THE VIRGINIA EARTH SCIENCE COMMUNICATION NETWORK. Joseph D. Exline, Science Service, Virginia Department of Education, Richmond, Va. 23216

During the 1974-75 academic year, a proposal, for increasing statewide communications in the science education community, was developed by the Virginia Department of Education Science Service. For the purpose of obtaining constructive criticism this proposal was shared nationwide with a number of scientists and science educators. On the basis of feedback, this proposal was revised and a communication network was initiated during the 1975-76 academic year.

This network has initially focused upon secondary earth science education because this area has been shown to be the major area of concern in the secondary science curriculum of the Virginia Public Schools. State, regional, and local level coordination is involved in this network. The system involves personnel from the Virginia Department of Education, nine colleges and universities, and all the local school divisions.

During its sixteen months of operation the communication network has had several accomplishments. Nine college-university coordinators have been identified and established as regional coordinators. A publication, entitled IMPART, is circulated statewide on a monthly basis. A proposal submitted to the National Institute of Education resulted in funding which has enabled the network to focus upon local level coordination.

DEVELOPMENT OF A MARINE EDUCATION CENTER AT VIMS. Susan C. Gammisch.\* Virginia Institute of Marine Science, Gloucester Point, Va. 23062.

With the increasing emphasis on marine matters and the importance of the sea comes a strong need for marine education. This need requires a shift in the content of existing educational materials. Marine education materials already exist, the problem is many of them are not readily available. The Virginia Institute of Marine Science is working to overcome this problem through the development of the VIMS - Sea Grant Marine Education Center, which will assist teachers in adding a marine emphasis to their courses.

In addition to developing a resource center, VIMS is devising a national Marine Education Materials System (MEMS) for the collection, storage, retrieval, and dissemination of marine education materials. Presently, it is extremely difficult for even the most persistent educator to obtain existing materials. The Marine Education Materials System will make it easier to retrieve any marine education material, whether it be curricula, field guides, lab manuals, film lists, or book lists. It will also provide a basis for determining the areas of greatest need for development of additional materials. Eventually this system will be computerized to facilitate the retrieval of requested materials.

THE EFFECT OF TWO INSTRUCTIONAL TECHNIQUES IN FACILITATING STUDENT COMPREHENSION IN CHEMISTRY AT THE COMMUNITY COLLEGE LEVEL. Leatrice A. Kaplan, Dept. of Natural Sciences, John Tyler Cmnty Col., Chester, Va. 23831.

Among the difficulties encountered by students at community colleges is their inability to understand the material in their texts. And, although science texts are amply illustrated, there are differences of opinion among researchers about the effectiveness of pictures in facilitating comprehension of scientific concepts and principles as described in textbooks.

The effect of two specific revisions of a chemistry text was examined to determine if comprehension would be increased more by improving the readability of the text material or by the use of line drawings with or without improving the readability of the text. The subjects were community college students with varying reading abilities.

Analysis of variance was used to determine which one of four treatment techniques was most effective in producing the highest gain scores. The results indicated that it was the rewriting and not the drawings that contributed to higher scores.

These findings are supported by previous findings that (1) improving the readability of college level science texts enhances information acquisition, and (2) illustrations can act as detractors to the information contained in prose passages. It is recommended that specially written text passages be designed for students in community colleges.

THE PROGRAMS AND PLANS OF THE SCIENCE MUSEUM OF VIRGINIA. P. H. Knappenberger, Jr., Director, Sci. Mus. of Va., Richmond, Va. 23220

The Museum opened its first exhibit area, the Discovery Room, in early January. Programs that involve direct participation with exhibits are conducted for scheduled school groups (grades 5-7 receive priority) and the general public. A traveling exhibit hall features exhibits on loan from science museums and various other sources.

The Museum's mobile unit, Trans-Science 1, is undergoing complete revision and will become a transportable solar laboratory, available for use by schools and community groups beginning in August.

A long-range plan for the adaptive reuse of Broad Street Station as a Museum facility has begun. Planning includes historic preservation, a major planetarium, exhibits and programs in selected areas of the physical sciences, health sciences, industry and technology, and natural history.

DESIGN AND USE OF A MOBILE LABORATORY FOR ENVIRONMENTAL STUDIES. H. B. Lantz, Jr. Orange County Public Schools, Orange, Va. 22960

The conducting of field studies for any extended period of time presents difficulties for the instructor in terms of transportation and storage of equipment and transportation and appropriate lodging for the participants. As a response to this need, the Environmental Education Program of the Orange County Public Schools, in cooperation with ESEA Title IV-C, has designed a mobile laboratory, using a renovated school bus. The unit is designed not only as a laboratory in the field but also as lodging for the student in the event of inclement weather. Thus, this mobile laboratory affords the instructor much latitude in mobility and flexibility of science-program offerings. In addition to being utilized for field studies by students in grades 5-12, the unit also serves as a water analysis laboratory for the county Soil Conservation Service.

ENVIRONMENTAL EDUCATION IN AN URBAN SETTING. C. A. McClaugherty\*. Maymont Foundation, Richmond, Va. 23220

Maymont Foundation is developing an environmental education program to supplement elementary school science classes and to encourage environmental awareness among the general public. The program utilizes an exhibit of animals indigenous to Virginia, a collection of over 200 woody plants, a children's farm, and a recently opened Nature Center housing living plants and animals.

Objectives are selected with assistance from Richmond Public Schools. Grades K-3 learn to use the five senses in nature study, and to relate the senses to survival. Grades 4-6 learn basic environmental principles. Teachers are provided with preliminary classroom activities. Curriculum specialists assist with feedback and evaluation.

CAN MATHEMATICS APTITUDE BE IMPROVED: SOME ENCOURAGING RESULTS! H. W. Straley, M. A. Robinson\*. Dept. of Mathematics, Woodberry Forest Sch., Woodberry Forest, Va. 22989.

The purpose of this study is to explore the effect of a supervised teaching experience on a student's mathematics aptitude. Instead of the conventional situation where one is exposed to mathematics only through a student-learning situation, this study examines the effect of a student-teaching experience on SAT-M scores.

By use of a matched pair design the investigators obtained significant differences in junior to senior SAT-M scores. The results support the conjecture that the student-teaching experience improves a student's mathematics aptitude as measured by the SAT-M.

AN ATTEMPT TO INTRODUCE P.I.E. (PLANNING/IMPLEMENTING/EVALUATING) CONCEPT IN THE TEACHING OF BASIC ECOLOGY COURSE AT VIRGINIA STATE COLLEGE. D.K. Sen, Dept. of Life Sciences and V. Thota\*, Dept. of Library Science & Educational Media, Virginia State College, Petersburg, Virginia 23803.

A Multi-Image Color Slide Tape Presentation is used to introduce students to the concept of a competency based modularized approach to instruction, with the emphasis on the student as the central concern. This presentation is introduced with a discussion of the Student-Centered P.I.E. Teaching Model developed by Dr. V. Thota and its application to the Ecology Course at Virginia State College. The structure and strategy is detailed through the experience of a Professor with an instructional problem moving through Ideas, People, Expertise and Team work.



## Section of Engineering

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

AN ANALYSIS OF ENERGY USE BY STATE FACILITIES AND INSTITUTIONS IN VIRGINIA. L. S. Fletcher and F. L. Huckstep\*. Dept. of Mechanical Engineering, Univ. of VA, Charlottesville, VA 22901

A study has been undertaken with the cooperation of the Univ. of VA, the VA Energy Office and the State Div. of Engineering and Buildings to develop an energy consumption analysis procedure for VA state facilities and institutions. Energy utilization measures have been developed for each institution based on monthly fuel and electricity consumption. Energy use data were analyzed in terms of climatological regions of the state, gross building area, and types of fuel used. These measures of energy utilization were designed to indicate how efficiently each institution uses energy, and to identify possible trends in energy use.

State facilities and institutions were divided into the following groups: four year universities and colleges, 2 year community colleges, hospitals, and other state offices and facilities. A comparison of the energy use of these facilities has provided some insight into energy management practices, guidelines for energy use, and recommendations for energy conservation.

THERMAL STRATIFICATION ENHANCEMENT IN HOT WATER TANKS. J. D. Lawrence\*, L. U. Lilleleht, Dept. of Chem. Eng., University of Virginia, Charlottesville, Virginia 22901

Widespread use of solar energy requires cost-effective means of collecting and storing solar energy for varying periods of time. One of the more common methods of doing this is by using flat plate collectors to heat water which is then stored in insulated tanks. Thermal stratification in the storage tank can increase the efficiency of the solar energy system.

An experimental investigation was undertaken to study the degree of thermal stratification in a 40-gallon cylindrical water tank of 3.5 to 1 length to diameter ratio with the axis vertical. Solar collector and load were simulated by heat exchangers using steam and cooling water, respectively.

Thermal stratification, with 15°C temperature difference between the top and the bottom, was achieved after 105 minutes under constant heat input and load. Installation of two inexpensive baffles to reduce mixing at water inlets improved the stratification significantly with a 30°C steady operation temperature difference obtained after approximately 90 minutes from the start.

CORONA DISCHARGE (KIRLIAN) PHOTOGRAPHY: DESIGN AND CONSTRUCTION OF PORTABLE APPARATUS. Wayne Richard\*, Robert Connelly\*, John Williams\*, and James O'Brien, Department of Psychology, Tidewater Community College, Virginia Beach, Virginia 23456.

Kirlian photography is the introduction of an object (organic or inorganic) into a high frequency, high voltage, low amperage field, which produces field images of these subjects on photographic film. The fingertips of humans in subjectively different moods, flora, metals and minerals are common subjects.

The potential of Kirlian photography as a diagnostic tool necessitates stable design and construction characteristics. Design of apparatus that is biomedically safe and portable when used in the field by a competent researcher is based on literature reviews and trial and error.

Design and construction requires the analysis of wave form characteristics, which include peak voltage, pulse repetition rate, and frequency components, all of which must be stable. Output timing control is also necessary. In addition, application variability can be increased by object/electrode configuration changes.

Some potential applications of this device include psychophysiological testing, metallurgy, biological specimen photography, and horticulture.

# Section of Environmental Science

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

ALTERATION OF SEDIMENTS AND INTERSTITIAL WATER DURING CREATION OF AN ARTIFICIAL MARSH IN THE JAMES RIVER ESTUARY - RELATIONSHIPS WITH TIME AND WITH A NATURAL MARSH. D. D. Adams\*, R.J. Young\* and D.A. Darby. Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508.

Ten sediment cores were taken in the navigational channel of the James River 14 km below Hopewell, Va in order to characterize the sediments and their interstitial water before dredging and establishment of an 8.1-ha artificial island. The sediments were fine ( $4.8\mu$ ), slightly reducing and acidic ( $\text{pH} = 6.63$ ), and possessed a CEC of 31 meq/100 g and 14% volatile solids. Interstitial and total nutrients (P and N species) suggested that these sediments would be an excellent substrate for marsh development. Interstitial metals ranged from high values for Ca (216 mg/l), Fe (57), Mn (6.9), and Zn (0.32) to low ppb levels for Pb, Ni, Cu, Cd and Hg (listed in order of decreasing concentrations).

During active dredging, Ca, Fe and Mn decreased to 10-30% of their porewater concentrations as a result of dilution with overlying water, oxidation, precipitation or coprecipitation. Cd, Cu and Zn concentrations at the effluent of the artificial marsh were higher, ranging from 100% to over 1000% increase as compared to porewater values. A noticeable improvement in the quality of the effluent was observed within one week after dredging. Cores were also collected in the artificial marsh 6, 19, and 24 months after dredging and from a natural marsh as a control. (Supported by WES, Grant No. DACW65-76-C-0039, Vicksburg, MI).

SIMILITUDE OF MASS TRANSFER PROCESSES IN DISTORTED FROUDE MODEL OF AN ESTUARY. Carvel Blair, Department of Mathematical & Computing Sciences, Old Dominion University, Norfolk, Va., 23508.

The Lafayette River is a small well mixed estuary in Norfolk, Va. A hydraulic Froude model with horizontal scale 1/540, vertical scale 1/12, was adjusted by means of roughness elements to attain substantial similitude of tidal hydraulics. Similar slug releases of Rhodamine WT dye tracer in model and prototype then produced concentration fields which were monitored in time and space over 8 tidal cycles. The normalized concentration fields proved to be in agreement, demonstrating the attainment of similitude of mass transfer processes.

For similitude to exist, the model-to-prototype ratio  $E_{TR}$  of longitudinal turbulent dispersion coefficients must have been of order  $10^{-4}$ . This value is predicted by the "Four-thirds Law" for dispersion. The Taylor-Elder approach through velocity shear analysis, by contrast predicts a value of order  $10^{-1}$  for  $E_{TR}$ . Lafayette River data thus suggests that the Four-thirds Law describes the process in this estuary. Analyses of eleven other recent model dispersion experiments lead to the same conclusion, while one additional model followed the Taylor-Elder prediction. Evidently the nature of the estuary determines which formulation of the dispersion coefficient applies.

DIURNAL AIR QUALITY MEASUREMENTS FOLLOWING A COLD FRONT PASSAGE. J. J. Buglia\*, H. S. Wagner\*, and G. E. Woodbury of NASA Langley Res. Ctr., Hampton, Va. 23665

A brief study was undertaken to determine how air quality measurements can be related to meteorological conditions that would be expected to produce higher ground level concentrations of pollutants. These measurements are consistent with the observations of Turner (1961) and Holtzworth (1973) of EPA who showed that urban air quality is affected by wind speed and stability conditions.

Several different measurement techniques were employed at ground level to characterize the hourly air quality during a 48-hour period following a cold front passage. The meteorological parameters were obtained from sensors placed at four levels on the 73 meter-high Impact Dynamic Research Facility. These air quality and meteorological parameters have been compared with simple models used to simulate the observed conditions.

Data taken for 2 consecutive days in November 1976 are compared. Mixing heights inferred from the temperature data were about 50 meters. Wind speed during the first day was calm for the period from 2400 to 0800 and were light for the corresponding period on the second day. Significant differences in the nocturnal CO concentrations were observed under these conditions. The variability in CO is attributed to the flushing action of the air.

SOME ENVIRONMENTAL EFFECTS INTRODUCED BY TALL BUILDINGS IN COASTAL CITIES. Kuldeep P. Chopra, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk VA. 23508.

Depending on ambient environmental conditions, tall buildings may exert a profound influence on the environmental characteristics of a coastal city and the rural regions beyond. These characteristics include temperature, wind, fogs and precipitation, and air quality. For example, a significantly large concentration of tall buildings is likely to enhance air, thermal and noise pollution, and increased frequency of fogs and precipitation. Under stable atmospheric conditions, tall buildings with parallel streets enhance the Bernoulli effect leading to strong drafts and pressure fluctuations. Moisture in air coupled with urban heat island effect and the availability of particulates generally tends to increase the frequency of occurrence of fogs and precipitation. Buildings of randomly varied heights, particularly with non-parallel streets, inhibit ventilation process and create pockets of stagnant, foul air. A planned sloping city skyline would create an artificial hill, improve the quality of air and aesthetic appearance of a city, increase land values and tax base over a larger portion of the city. A side benefit would be the possibility of transport of water through enhanced orographic cooling to areas further inland.



SEDIMENTOLOGICAL COMPARISON OF A NATURAL AND A DREDGE SPOIL MARSH IN THE JAMES RIVER ESTUARY. D. Darby and D. D. Adams\*. Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508

A comparison of an experimental marsh with a nearby natural marsh was made as part of an assessment of the desirability of creating freshwater tidal marshes from James River channel dredgings. Deposition of poorly sorted ( $\sigma=3.1\phi$ ), fine-grained sediment with a mean size of  $7.56\phi$  ( $5\mu$ ) from a dredge slurry of 15% solids resulted in a flocculated, homogeneous sediment in the experimental marsh. The natural marsh sediment is finer grained with a mean size of  $8.97\phi$  ( $2\mu$ ) and poorly sorted ( $\sigma=2.9\phi$ ), but contains slightly better developed laminae due to the slow accumulation of tidally suspended sediment. The initial water content, volatile solids content, and shear strength of the experimental marsh sediment were lower than the natural marsh. Of these, only the volatile solids increased significantly, from 4.5 to 10.9 percent in 18 months. Irregardless, the sediment cation exchange remained between 30-40 meq/100g compared to 66 meq/100g in the natural marsh. Thus, the experimental marsh may in time approximate a natural marsh in some characteristics but major differences will remain. (Aided by WES, Corps of Engineers).

REMOTE MEASUREMENT OF SURFACE TEMPERATURE BY RADIATION THERMOMETERS<sup>†</sup>. S. K. Gupta\*, and S. N. Tiwari, School of Engineering, Old Dominion Univ., Norfolk, Va. 23508

A simple procedure has been developed for applying atmospheric correction to the surface temperature measured remotely by a radiation thermometer, flown at mid-tropospheric altitudes. Line and continuum absorption by water vapor have been taken into consideration to evaluate the attenuation of the surface radiation in the spectral region (11 $\mu$  window) of the instrument. Implications of the temperature dependence of the continuum absorption coefficients to the measured surface temperature are discussed in detail. Effects of the uncertainties in the distributions of water vapor and atmospheric temperature on the measured surface temperature are also examined. Model calculations have been performed to establish empirical relations between the deviations of the relevant atmospheric and surface parameters from their standard values and the resulting additional corrections required for the measured surface temperature.

<sup>†</sup>Supported by NASA-Langley Research Center, Grant NSG-1282.

THE EFFECTS OF TEMPERATURE AND SALINITY ON THE LARVAL DEVELOPMENT OF THE GRASS SHRIMP, *PALAEMONETES PUGIO* REARED IN THE LABORATORY. W. R. FLOYD\*. Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508.

*P. pugio* larvae, obtained by induced breeding of adults from the Lafayette R., Norfolk, Va., were reared in the lab using a six temperature (10°-32.5°C) by seven salinity (5-35 ‰) factorial design in order to determine the effects of these factors on their development. At each of the 42 T-S combinations, 36 zoeae were reared individually using 25 ml of artificial seawater with 25 wppm of polyethylene oxide added to reduce deaths due to stranding. Food consisted of 30 *Artemia* nauplii/ml of culture water. Results indicated that temperature, salinity, and their interaction have a highly significant effect on survival, larval duration, number of molts, and intermolt duration. Nearly 100% survival to metamorphosis can be expected at the optimum conditions of 20°-30°C at 20-25‰. From 15° to 30°C, mean larval duration decreases with increasing temperature from 116.5 to 16.7 days. Individual zoeae had a range of from 11 days at 30°C-35‰ to 184 days at 15°C-25‰. The mean number of molts to post-larva is lowest (8.1 and 8.3) at 20° and 25°C, with increases to 11.3 molts at 32.5°C and 13.4 molts at 15°C. Individual zoeae had a range of from six molts at 30°C-35‰ to 20 molts at 15°C-30‰. From 15° to 32.5°C the mean intermolt duration decreased with increasing temperature from 8.7 days to 1.7 days. Individual zoeae had a range of from 1.45 days at 32.5°C-25‰ to 10.2 days at 15°C-25‰.

CIRCULATION STUDY NEAR CAPE HENRY, VIRGINIA, USING LAGRANGIAN TECHNIQUES. R. E. Johnson. Inst. of Oceanography, Old Dominion Univ., Norfolk, VA. 23508

Further study of the circulation near Cape Henry, Virginia, has been made using surface and seabed drifters and radar-tracked surface buoys coupled to subsurface drag plates. Drifter releases were conducted on a line normal to the beach just south of Cape Henry. Surface drifter recoveries were few; wind effects were strongly noted. Seabed drifter recoveries all exhibited on-shore motion into Chesapeake Bay. Strong winds also affected sea bed recoveries, tending to move them farther before recovery. Buoy trajectories in the vicinity of Cape Henry appeared to be of an irrotational nature, showing a clockwise rotary tide motion. Nearest the cape, the buoy motion elongated to almost parallel depth contours around the cape. Buoy motion under the action of strong winds showed that currents to at least the depth of the drag plates substantially are altered from that of low wind conditions near the bay mouth. Only partial evidence could be found to support the presence of a clockwise non-tidal eddy at Virginia Beach, south of Cape Henry.

INTERSTITIAL DISSOLVED MERCURY AND CARBON ASSOCIATIONS IN AN ARTIFICIAL AND NATURAL MARSH ON THE JAMES RIVER. A. Katsaounis\*. Inst. of Oceanography, Old Dominion Univ., Norfolk, VA 23508.

The transport and deposition of mercury in the estuarine environment is largely controlled by its interaction with natural organic matter. Sediment pore water in estuarine sediments is enriched in both dissolved organic matter and dissolved mercury relative to overlying water. Field and laboratory studies indicate a seasonal difference with respect to these two parameters with higher concentrations occurring during the summer. The concentrations of dissolved organic matter and dissolved mercury were lower at a reference marsh near Ducking Stool Point on the James River 12 km below Hopewell, VA than at an artificial marsh created from recently deposited fine-grain channel sediments. This was probably due to higher concentrations of dissolved organic carbon in the interstitial water of the artificial marsh as compared to the reference marsh and resultant interactions with mercury in the sediments. The mean concentrations of dissolved organic carbon and dissolved mercury for 18 cores and at three depths within the cores are as follows: August 1976 for the artificial marsh (36.1 mg/l DOC and 4.59  $\mu$ g/l diss. Hg) and reference marsh (28.3 mg/l DOC and 3.99  $\mu$ g/l diss. Hg); January 1977 for the artificial marsh (19.9 mg/l DOC and 0.82  $\mu$ g/l diss. Hg) and reference marsh (15.6 mg/l DOC and 0.64  $\mu$ g/l diss. Hg). Support for this study was from WES, Vicksburg, MI.

CATION EXCHANGE CAPACITY AND EXCHANGEABLE CATIONS IN THE JAMES RIVER SEDIMENTS. William Nivens\*, Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508

Sediment samples collected from the 0 to 10cm and 24 to 50 cm depth intervals in cores from a dredge disposal marsh and a nearby natural marsh. 16 kilometers downstream from Hopewell on the James River were subjected to an ammonium acetate extraction. Nine metals (Ca, Fe, Mn, Zn, Cu, Cd, Pb, Ni and Cr) were analyzed from this extraction by atomic absorption spectrophotometry in order to determine the amount of these metals occupying cation exchange sites on sediments. Only the first four metals were above detection levels and their sum accounted for less than 20 percent of the average cation exchange capacity (CEC) at the dredge disposal marsh (30 Meg/100g) and natural marsh (63 meg/100g). Other probable cations occupying exchange sites are potassium, magnesium, sodium, hydrogen and ammonium. This last cation was 1 to 4 ppm in the sediment porewater. Most of the CEC was due to clay minerals because removal of organic matter by H<sub>2</sub>O<sub>2</sub> resulted in only a 30 to 35 percent reduction in CEC while removal of iron colloids and coatings reduced the CEC another five percent. Supported by Army Corps of Engineers' Grant #DACW65-76-C-0039, Vicksburg, MI)



ESTIMATES OF ATMOSPHERIC MIXING LAYER HEIGHTS FOR THE SOUTHEASTERN VIRGINIA POLLUTION EXPERIMENT. E.E. Remsburg and J.J. Buglia\*, NASA Langley Research Center, Hampton, VA. 23665; J.E. Smith\*, Dept. of Physics and Geophysical Sciences Old Dominion University, Norfolk, VA 23508

The State Air Pollution Control Board (SAPCB) in Region 6, Southeastern Virginia, has been measuring relative maxima in ground level carbon monoxide (CO) concentrations during the evening and early morning hours, especially during the fall and winter months. This maximum does not coincide with peak automobile traffic, a major source of carbon monoxide. A joint field experiment was conducted by SAPCB, NASA-Langley, and Old Dominion University researchers to determine the role of atmospheric parameters on the diurnal variations of CO. One parameter, the atmospheric mixing height, was inferred with lidar, acoustic sounder, and radiosonde balloon. Additional temperature profiles from an instrumented tower resolved a low-level mixing height (50 meters) which occurred due to radiation cooling at night. This data set along with surface wind speeds has been applied to dispersion calculations for carbon monoxide. The dispersion is time dependent and includes a realistic emission estimate for local traffic. The predicted CO curve compares very well with the observed relative CO maximum at night. This study indicates that the observed nighttime CO "anomaly" can be attributed to the traffic pattern and the prevailing atmospheric conditions. Methods for predicting the occurrence of those conditions are discussed.

THE ROLE OF SEDIMENT AND INTERSTITIAL PHOSPHORUS IN A FRESH-WATER TIDAL MARSH, JAMES RIVER, VIRGINIA. D. L. Stealey\*, Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508

Since sediments may actively contribute to the nutrient supply of natural waters, a study to define the role of sediment and interstitial water in the biogeochemical cycle of phosphorus has been undertaken. The water column, sediment, and interstitial water of a freshwater tidal marsh near Ducking Stool Point, James River, Virginia, were analyzed for characteristic concentrations of phosphorus.

Total dissolved phosphorus (TDP) averaged 187  $\mu\text{g/l}$  in interstitial water as compared to dissolved inorganic phosphorus (DIP) concentrations averaging 57  $\mu\text{g/l}$ . Concentrations of TDP and DIP in the water column averaged 57 and 34  $\mu\text{g/l}$ , respectively. Further analysis is underway attempting to reflect the breakdown of phosphorus compounds to DIP with depth in the sediment column.

Phosphorus concentrations in natural waters are controlled by pH, redox potential, and organic matter content. Other variables presently under consideration include the concentration of calcium, manganese, iron, and the sediment mineralogy. (Supported by Army Corps Engineers' Grant No. DACW65-76-C-0039, Vicksburg, MI).

TIDAL TRENDS FOR DISSOLVED TRACE METAL CONCENTRATIONS AT A NATURAL AND ARTIFICIAL FRESH WATER MARSH AND THEIR RELATIONSHIPS TO GEOCHEMICAL PARAMETERS AT THE MARSHES.

R. J. Young\*, D. D. Adams\*, and D. A. Darby, Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508.

Samples for dissolved and particulate trace metals were collected hourly and in duplicate at each of four tidal channels contiguous to two marshes on the James River near Hopewell, Va over a 48 hour period in August 1976 and a 53 hour period in January 1977. Two stations were located at the entrance to a natural marsh while two stations were situated at an artificial marsh composed of recently deposited dredged channel sediments. In addition to the water column metals, both bulk and interstitial metal concentrations were analyzed for Ca, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, and Zn from cores collected in triplicate at each of three locations at each marsh. These locations correspond to different intertidal elevations.

Tidal cycles of dissolved Fe, Mn and Ca will be discussed with relationship to porewater/water column concentration ratios and other factors influencing mixing or chemical availability. (Supported by Army Corps of Engineers' Grant No. DACW65-76-C-0039, Vicksburg, MI).

SURVIVAL, DURATION OF LARVAL STAGES, AND SIZE OF POSTLARVAE OF GRASS SHRIMP *PALAEMONETES PUGIO* REARED FROM KEPONE CONTAMINATED AND UNCONTAMINATED POPULATIONS IN CHESAPEAKE BAY. K.B. Schmitz\*, A.J. Provenzano, and M.A. Boston\* Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508.

Life stages of *Palaemonetes pugio* collected from six sites within Chesapeake Bay, when analyzed for Kepone, showed variation in concentration ranging from undetectable to levels of 0.6 ppm. Populations from the James River and nearby Lafayette River showed the highest concentrations of Kepone; distant populations showed lower levels. Larvae of *P. pugio* obtained from three adults collected at each of the six sites, when reared under controlled laboratory conditions, showed no significant differences in larval survival, larval duration, or length of postlarvae attributable to site of origin. Laboratory reared postlarvae representing all six populations had very low or undetectable Kepone concentrations.

Although intersite variation was not significant with respect to larval development time and postlarval length, parental variation was highly significant.

A weak, but significant relationship was found between development time and postlarval length at metamorphosis.

NITROGEN FIXATION IN VIRGINIA SALT MARSHES. A.D. Thomson and K.L. Webb, Dept. Ecology-Pollution, Va. Inst. of Mar. Sci., Gloucester Point, Va. 23062.

$\text{N}_2$  fixation rates for several Va. salt marshes were determined using in situ acetylene-reduction assays. A control and a chronically polluted oil marsh of the mesohaline Mobjack Bay area were sampled over a 1975-76 annual cycle.  $\text{N}_2$  fixation occurred in all transects which extended from upper mudflat to the *Spartina patens* zone. An isolated blue-green algal mat exhibited some of the highest  $\text{N}_2$  fixation rates. Intertidal sediment  $\text{N}_2$  fixation was patchy, both spatially and seasonally. However average rates (91.45  $\mu\text{g N/m}^2/\text{h}$ ) compared to the estimated N requirement of the graminoid vegetation indicates a significant contribution to the N budget. Vegetation-associated nitrogen fixation yielded higher average rates.  $\text{N}_2$  fixation rates for Wachapreague high salinity and Yorktown relic low salinity marshes were similar to the mesohaline marshes although blue-green algae fixation seemed to be more significant.

The mesohaline seasonal pattern of fixation was positively related to temperature. Light-dark and anaerobic-aerobic experiments support the hypothesis that heterotrophic bacteria are the predominant  $\text{N}_2$  fixers and that availability of oxidizable substrates contribute to the seasonal pattern. Chronic oil treatment showed little effects on fixation rates with the possible exception of median tidal elevation sediments where summer rates were considerably higher than those of the control.

IRON-SALINITY RELATIONSHIPS IN THE POREWATERS OF THE JAMES RIVER SEDIMENTS.

C. L. Young\*, D.D. Adams\*, and D. A. Darby, Inst. of Oceanography, Old Dominion Univ., Norfolk, VA 23508

Preliminary investigations indicated that the concentration of dissolved interstitial iron may be a function of salinity in the sediments of the James River estuary. Dissolved interstitial iron in the surficial sediments of the Chesapeake Bay at a salinity of approximately 220/00 was 0.38 mg/l. In a fresh water environment in the James River 14 km below Hopewell, VA, the concentration of dissolved interstitial iron was about 45 mg/l in the 0-15 cm horizon of the surface sediments. In order to further investigate the iron-salinity relationship, additional samples were collected in January 1977 from a salinity regime of 160/00 near the mouth of the James River to near zero salinity at Windmill Point. Interstitial water was immediately removed from the 5-15 cm portion of each core by pressure squeezing with nitrogen under an inert atmosphere. Sediment iron and dissolved interstitial iron were analyzed by atomic absorption spectrophotometry. The results of these investigations will be discussed. (Partial support from Army Corps Engineers' Grant No. DACW65-76-C-0039, Vicksburg, MI).



## Section of Geology

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

ENTRAINMENT VELOCITIES OF SOME SAND-SIZE HEAVY-MINERAL PARTICLES. L. D. Ambrose. Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

This paper concerns itself with the study of the effects of size, specific gravity, shape, and bottom roughness on the water velocity required to erode sand-size particles.

The cause-effect relationship of the variables is complex and not well understood. The results of this paper show that settling velocity by itself does not adequately reflect the entrainment velocity of sand-size particles.

Particle shape and specific gravity greatly influence the velocities required to move particles. For planar or nearly planar beds, the effect of these variables on entrainment velocities are reflective of settling velocities, but as bottom roughness increases so do the entrainment velocities at an ever increasing proportion.

Bottom roughness was found to be as important as specific gravity, size, and particle shape as a variable of entrainment.

At present, theoretical treatment of sediment transport is unable to predict entrainment of particles when all variables work in concert.

VERTICAL ELECTRICAL SOUNDINGS ON THE EASTERN SHORE OF VIRGINIA. R. I. Carroll\*, J. W. Cross\*, M. A. Foster\*, N. J. DeRose\*, and R. S. Spencer. Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

Investigations of the availability of ground water, complemented with the possible mapping of the aquifers and the salt water-fresh water interface.

The Schlumberger array of depth soundings was used with a total spread distance of 4,000 feet to reach a depth of approximately 500 feet. Six soundings were made within a radius of six miles. Data reduction to a five layer model and a ten layer model interpretations were made possible by usage of an automatic interpretation computer program written by A. A. H. Zohdy, 1972, which matched parameters of  $\rho$  and  $h$  between the calculated and the observed resistivity curves.

Because of the inherent limitations of Vertical Electrical Soundings, the interpretations obtained with the computer programs are mathematically correct, but should be viewed as parastratigraphic units. Stratigraphic correlation is feasible with the positioning of one sounding close to a U.S.G.S. test well site in the southern region of the study area. (Funded by NSF-SOS grant SMI 76-08399)

APPLICATIONS OF A COMPUTER PROGRAM FOR SIZE ANALYSIS IN A SOIL SURVEY IN NORTHAMPTON COUNTY, VA. J. W. Cross\*, R. I. Carroll\*, M. A. Foster\*, and R. S. Spencer. Dept. of Physics & Geophysical Sciences, Old Dominion Univ., Norfolk, Va. 23508

A soil survey was conducted in a portion of Northampton County, Virginia as a supplement to an Environmental Impact Survey during the summer of 1976. Most soil types found on the Eastern Shore have drainage problems due to the absence of substantial relief, low altitudes, high surface water tables, and a general deficiency in natural drainage systems. In addition, the fine texture of the marine and estuarine sediments that compose the soils has a tendency to inhibit vertical drainage. Considerable attention was devoted to the particle size distributions and associated statistical parameters of the soils sampled. This information was largely attained by a computer program for sediment size analysis. The size analysis data was treated in several ways. Initially, the size analysis data aided classifications of the soils into the three major classification schemes most commonly used. Additionally, information concerning mean particle size and how well the size ranges of the samples were distributed were used to determine the extent of post depositional clay infiltration, the uniformity of climatic conditions affecting the different soil types, and the consistency of particle size distributions within each soil type surveyed. In conclusion, the computer analysis aided in recommendations concerning surface and ground water contamination. (Funded by NSF-SOS grant SMI 76-08399)

STRONTIUM IN THE TONOLOWAY LIMESTONE. Helly B. Gideon\*. Dept. of Geology, Madison College, Harrisonburg, VA 22801

The Tonoloway limestone is a thin-bedded upper Silurian formation. Its eastern extent outcrops along the Virginia-West Virginia border. Strontium in the form of the mineral celestite was collected from the Tonoloway near Winchester, Virginia and described by Rodgers (1964). For this study 43 samples were taken from 2 locations of the Tonoloway in order to determine the amounts and distribution of strontium within the formation. Samples were divided into 5 groups based on lithologic characteristics. Each sample was analyzed for insoluble residue content, and strontium/calcium ratios within the acid-soluble fraction were determined by atomic absorption spectrophotometry. The massive, medium-grained lithologic group produced 3 strontium values that were very high compared with all other samples. The overall mean was 1739 parts strontium per million parts calcium, with the 3 very high strontium-content samples averaging about 10000 parts per million. Strontium content versus insoluble residue fraction was also investigated but no correlation appears to exist. Thin section studies have indicated that much of the original sediment forming the Tonoloway may have been aragonite pellets rich in strontium. Formation of intraclasts and recrystallization of portions of the formation provide mechanisms for the mobilization of strontium and may account for the large differences in strontium/calcium ratios within the formation.

A GEOPHYSICAL STUDY IN GLOUCESTER AREA, VIRGINIA. Marie T. Ingram\*. Dept. of Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508 (Sponsored by M. Sabet)

The study consisted of: digitization of the aeromagnetic maps at  $\frac{1}{2}$  mile interval in the area defined by the latitudes  $37^{\circ}15'$  and  $37^{\circ}37.5'$ , longitudes  $76^{\circ}15'$  and  $76^{\circ}45'$ ; establishment of a gravity map of the area; gridding both gravity and magnetic maps at a grid interval of 5208 ft.; smoothing both sets of data by application of Hamming window; downward continuation of both maps; transformation of magnetic map to the magnetic pole; upward continuation of gravity map to the height of 500 ft.; calculation of the first vertical derivative of gravity map at 500 ft.; and, finally, comparison between magnetic map transformed to the pole and the first vertical derivative gravity map, in order to estimate  $J/\rho$  through the use of the Poisson's relation. All these operations were performed on the computer through the use of the Fast Fourier Transform algorithm. The results suggest that the minimum depth to the top of the source of the anomalous mass is about 2500 ft. The average value of  $J/\rho$  is .019 c.g.s. units, thus a magnetic susceptibility contrast of .008 c.g.s. units was estimated, which corresponds to about 4% excess magnetite by volume. It is concluded that the anomalies are caused by intrabasement sources of considerable thickness. Transformation of the magnetic map to the pole did not entirely remove a magnetic low in the NE part; thus suggesting that the anomalous mass is polarized by a magnetic field which differs in direction from the present field.

FLUORO-SILICATES IN THE FRANKLIN MARBLE, ORANGE CO., N.Y. Lance E. Kearns\*, Dept. of Geol., Madison Col., Harrisonburg, Va., 22801

The Grenville-age Franklin Marble forms a narrow, north-east-southwest trending belt along the western edge of the New York-New Jersey Highlands. Mineral studies and K-Ar age dates indicate that the minerals contained within the Franklin Marble of Orange Co., N.Y. are the result of a single, regional metamorphic event ( $840 \pm 35$  M.Y.).

Calcite-dolomite geothermometry indicates a minimum metamorphic temperature of approximately 860 degrees C. Mole fraction of  $\text{CO}_2$  in the fluid phase was estimated between 0.75 and 1.00 from the reaction dolomite + 2 quartz  $\rightarrow$  diopside +  $2\text{CO}_2$ . Pressure ( $P_f = P_r$ ) values of 4 to 7 kbars. were inferred from the calcite + quartz  $\rightarrow$  wollastonite +  $\text{CO}_2$  univariant curves for  $\text{XCO}_2$  of 0.75 and 1.00.

Mineral assemblages containing hydrous-silicates are found abundantly in the marble. Examination of the stability fields for these assemblages indicates an apparent incompatibility with the inferred metamorphic conditions. Fluorine contents of the hydrous-silicates were found to be extremely high; the hydrous-silicates are in effect fluoro-silicates. The high fluorine content of the hydrous (fluoro)-silicates is believed to be responsible for preserving these assemblages at high temperatures.

THE CARTERS BRIDGE, VIRGINIA, EARTHQUAKE OF FEBRUARY 27, 1977. Dave Lasch\*, Va. Div. of Mineral Resources, Charlottesville, VA 22903

The Carters Bridge, south-central Albemarle County, earthquake occurred at approximately 20:05:37 UTC on February 27, 1977. The magnitude of the earthquake was determined to be 2.4 (Richter scale). An intensity survey was conducted which indicated a maximum intensity of IV (Modified Mercalli scale) for the earthquake. An attempt has been made to correlate the regional geology, in a tentative manner, with the isoseismal map.

DESCRIPTION OF A CARBONATE CONGLOMERATE AND GRAINSTONE SEQUENCE WITHIN THE MIDDLE ORDOVICIAN LIBERTY HALL FM., NEAR NEW ELLETT, VA. S. O. Moshier\*. Dept. of Geological Sciences, VPI & SU, Blacksburg, Va. 24061

A 130 foot thick sequence of carbonate conglomerates and grainstones occurs within the Middle Ordovician Liberty Hall Fm., near New Ellett, Va. Six lithologies are represented in the sequence. They include three varieties of paraconglomerates, a polymictite, laminated fossil and pellet grainstones and argillaceous lime mudstones. The paraconglomerates are distinguished by clast and groundmass characteristics. Laminated grainstones show graded beds and cross laminations. The argillaceous lime mudstone displays extensive solution cleavage, nearly perpendicular to bedding, and contains some clasts. The sequence is enclosed by dark shaly siltstones, common to the Liberty Hall Fm. in this area.

Deposition could be a result of allochthonous debris flows, shoaling or channeling. Primary sedimentary structures in the grainstones suggest downslope transportation (allodapic origin) but fossils appear to have been subject to limited movement. The "shallow water" lithologies represented by the conglomerate clasts certainly indicate the proximity of a carbonate buildup or shelf margin at the time of their deposition in this sequence.

DETERMINATION OF AXES OF STRAIN USING FOLDED AND STRETCHED DIKES IN THE FREDERICKSBURG COMPLEX, VIRGINIA. W. S. Nye\*, and R. V. Amenta, Dept. of Geology, Madison College, Harrisonburg, Va., 22801

Measurements of poles to folded and non-folded (stretched) dikes in the Fredericksburg Complex near Motts Run Reservoir were plotted in stereographic projection in an attempt to define the mean axes of compressional strain, X, and extensional strain, Z, after the method of Talbot (Tectonophysics, 1969). X plotted  $14^{\circ}$  from the mean of poles to foliation,  $X_p$ . Biased sampling due to cut effect of the exposure surface, a stream bed, precluded measurements on dikes with orientations parallel to this surface. Poles to such dikes would have shifted X closer to  $X_p$  in stereographic projection thus permitting an interpretation that the foliation formed normal to X. A mineral lineation is present on the foliation at an angle of  $40^{\circ}$  to fold axes. We propose that this lineation lies parallel to the mean axes of extensional strain, Z.

FORAMINIFERAL DISTRIBUTION AND ABUNDANCE PATTERNS IN THE LOWER CHESAPEAKE BAY. Pamela K. Painter and R. S. Spencer. Dept. of Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508.

This preliminary study is to determine foraminiferal distribution patterns of various species occurring in the lower Chesapeake Bay and their possible relation to environmental factors. By far, *Elphidium clavatum* is the most abundant and most wide spread species in the lower Chesapeake Bay. In general, the polyhaline (16.5-30.0 o/oo) species occur in greatest abundance near the bay mouth and along the western boundary of the Eastern Shore. A more saline tongue extending from the bay mouth to the York River mouth at a depth of 12 m may be responsible for polyhaline species being found close to the mouth of the York River. Surface salinity is also relatively high in that area. Depth seems to display a secondary control on the abundance of these forms with shallower stations showing higher counts. In some cases, these higher salinity species show anomalous occurrences near the Rappahanock River mouth. One possible explanation is that they were transported to this area by storm currents. Because this anomalous situation is present at the same stations for many different species of polyhaline foraminifers, a second explanation may be that these represent samples from submerged Pleistocene outcrops.



PALEOECOLOGICAL AND COMMUNITY ANALYSIS OF THE MIDDLE ORDOVICIAN BENBOLT FORMATION NEAR SPEERS FERRY, VIRGINIA. Bryan H. Roberts\*. Dept. of Geology, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

The Middle Ordovician Benbolt Formation 4½ miles SW of Speers Ferry, Scott County, Virginia is overlain by the Wardell Formation and underlain by the Rockdell Formation. The unit here ranges from skeletal mudstones to packstones with interbedded shales and represents an open marine shelf environment.

Two communities are present in the unit at this location and are recognized as the Sowerbyella spp. community and the Strophomena spp. community. The dominant members of the Sowerbyella community are Sowerbyella compacta Cooper and Sowerbyella sp., whereas the Strophomena community includes species of Macrocoelia, Rafinesquina, and Strophomena. Statistical analysis of the faunal data shows a greater species enrichment for the Strophomena community than the Sowerbyella community. This is most noticeable at the individual collection (faunal slab) level where the Sowerbyella community averaged 9.5 species per slab compared with 13.2 species per slab for the Strophomena community.

Various factors which may have separated the two communities are fluctuations in salinity, temperature, and suspended sediments, the type of substrate, and biological competition. All of these, either alone or in combination, may have operated.

CONTROLS ON SINKHOLE FORMATION IN THE SHENANDOAH VALLEY AROUND LEXINGTON, VA, AND IMPLICATIONS FOR LAND USE. L. A. Rossbacher, Dept. of Geology, Dickinson College, Carlisle PA 17013

There are a number of factors that control the development of karst depressions. Sinkholes in the Lexington, VA area were studied through maps and field work, and locational controls were found to include lithology (especially  $\text{CaCO}_3$  and insoluble residue content), topographic slope aspect and degree, and distance above the water table. Sinkhole morphology can be correlated with local structures, structural trends, and bedding characteristics.

It appears that areas around Lexington that have the highest probability of sinkhole development will be those underlain by the Middle Ordovician, high- $\text{CaCO}_3$  Lincolnshire Limestone (or along any formational contact or fault) on south facing slopes of less than  $10^\circ$ . Uplands above the entrenched Maury River are also conducive to sinkhole formation.

Although this analysis of potential sinkhole development only considers limited aspects of the area, it can be used for rapid and inexpensive preliminary evaluations by site-specific investigations.

LOWER SILURIAN TUSCARORA (CLINCH) DISPERSAL PATTERNS IN WESTERN VIRGINIA. Robert C. Whisonant, Dept. of Geology, Radford College, Radford, Virginia 24142

The Tuscarora Sandstone (Clinch equivalent) is a basal Silurian orthoquartzitic sandstone prominently exposed in the Valley and Ridge province of western Virginia. Directional analysis of paleocurrent structures and grain size distribution indicates that the Tuscarora-Clinch clastic material was deposited on a paleoslope that dipped uniformly northwestward. The provenance area was an extensive line source located in the Blue Ridge - Piedmont complex eastward of the present outcrop belts. The basin-source contact (paleo-fall line) for the Tuscarora-Clinch deposits was evidently situated some 80 km farther east of the present Valley and Ridge - Blue Ridge boundary prior to late Paleozoic folding and faulting. (Aided by Geological Society of America Penrose Grant 1616-72)

# Section of Materials Science

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

## Stress Corrosion Cracking of HERF Type 316 Stainless Steel

by T. S. Allen and M. R. Louthan, Jr.

The thermomechanical process of High Energy Rate Forging (HERF) increases both the strength and toughness of normally processed Type 316 stainless steel. Although Type 316 stainless steel is widely used as an orthopaedic implant material, it is lacking in both the strength and corrosion resistance required for this application. The shape of such implants is conducive to the HERF process, and because of the potential for improved mechanical properties the process may have immediate applicability in implant fabrication if the HERF treatments do not reduce the resistance of the material to corrosion and stress corrosion cracking.

Experimental studies with HERF Type 316 pancakes, provided by Sandia Corporation, Livermore Laboratories, have shown that the resistance of the material to stress corrosion cracking in boiling  $MgCl_2$  solution is improved by the thermomechanical treatment and have indicated that the general corrosion resistance is not impaired. The results of these studies are described in this report.

## HVEM STUDIES OF ELECTRON-ION RADIATION DAMAGE. J. I. Bennetch\*, J. A. Horton\* and W. A. Jesser, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901

Much research for the past ten years in the field of radiation damage concerns radiation induced swelling by void and bubble formation. High flux ion and electron beams have both been utilized in studies of this phenomenon. Using a flux of helium ions comparable to those reported in the literature, the authors investigated the nature of the ion beam itself. After the beam, coming from a high purity source, was found to consist of as many as five different components, experiments were conducted to identify each component. The relative importance of each one to the production of blisters is being determined. *In situ* HVEM experiments together with a spectrographic analysis of the gas content of the blisters are being conducted to determine the role of helium in blister formation in 304 and 316 stainless steel under bombardment by heavier gas ions.

The financial support of the Energy Research and Development Administration, Division of Magnetic Fusion Energy, is gratefully acknowledged.

## DETERMINATION OF LOSS AND WEAR DATA ON ELECTRICAL BRUSHES. S. Dillich\*, V. Srikrishnan\* and D. Kuhlmann-Wilsdorf, Dept. of Mat. Sci., Univ. of Va., Charlottesville, VA 22901

Measurements are presented of the electrical and mechanical losses in high current density 70% silver/30% graphite brushes (Stackpole SG142). These were made in air, during short periods of time, at constant rotor speeds (1000, 3000, and 5900RPM) and current densities (120, 640, 1280 and 2050 amperes per square inch). Experimentally, the total loss goes through a minimum as the brush load is gradually increased. The minimum value of the total loss is found to increase with increasing current density and rotor speed.

Measurements were also made in  $CO_2$  atmospheres with humidities ranging from 0-100%. As has been known for some time, wear of the brushes is extremely rapid at very low humidity; while sparking and the resulting brush damage is observed at high humidities. Thus, acceptable brush performance is restricted to intermediate humidities.

The mechanical losses and coefficients of friction were uniformly lower in the  $CO_2$  atmospheres than in air.

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## HYBRID DENTAL COMPOSITES. O. Hodgins\*, F. E. Wawner and K. R. Lawless, Dept. of Mat. Sci., Univ. of Va., Charlottesville, VA 22901

The majority of recent studies in this field have concentrated on comparative evaluation of commercial composites. Although showing superior properties compared to earlier materials, these composites still lack sufficient mechanical properties.

Data generated in the existing NIDR program at the University of Virginia show greatly improved strength, hardness and wear resistance by utilizing concepts of two dimensional reinforcements (glass cloth discs). The cloth of glass fibers ( $Al_2O_3$ , aluminoborosilicate, and others of acceptable index of refraction) are positioned in strategic locations in a composite restorative in order to impart strength and stiffness and abrasion resistance to the exposed surface.

In the case of the glass cloth it will present a larger area for bonding to the resin as well as having a mechanical interlocking with other fibers in the cloth. The cloth is pressed into the resin (matrix) into close proximity to one another until restoration is completed. This concept is used to form a hybrid composite which will lead to a vastly improved dental composite restorative.



CORROSION STUDIES OF DENTAL AND SURGICAL INSTRUMENTS DURING STERILIZATION. R. Larmouth\* and G. E. Stoner\*, Dept. of Mat. Sci., Univ. of Va., Charlottesville, VA 22901

Corrosion has long been recognized as a materials problem. An area of corrosion which may not be apparent concerns dental and surgical tools. These tools, especially the carbon steel type, undergo severe corrosion when sterilized in an autoclave. This corrosion is most severe where it is least desirable, near a cutting edge or other sharp, functional part of the tool or instrument.

Several methods aimed at preventing this corrosion include the addition of phosphate compounds to the sterilizer, protective coatings and organic nitrogen base inhibitors. However, none of these ideas have proven to be completely satisfactory. A description of the methods used to evaluate corrosion plus a discussion of several aspects of prevention will be presented.

ION-MILLING OF TOOTH ENAMEL FOR TEM. A. Marshall\* and K. R. Lawless, Dept. of Mat. Sci., Univ. of Va., Charlottesville, VA 22901

The transmission electron microscope is a useful tool in studying ultrastructural changes in tooth enamel as a result of the caries (decay) process. Unfortunately, the thinning of tooth enamel for TEM is a difficult proposition, as enamel is an extremely hard tissue and therefore cannot be easily sectioned on a microtome. Ion-milling is a possible alternative, and, in theory, should introduce less damage into the crystalline structure than is caused by microtoming.

The process of ion-milling involves an atom-by-atom removal of the specimen material by a stream of argon ions. The major drawback of this technique is that it is very slow. It has been used successfully however, to produce enamel thin sections of good quality. Preferential etching by the beam and damage to the tooth structure appear to be minimal.

COMPARISON OF DAMAGE MECHANISMS TO STIFFNESS CHANGES AND STRENGTH REDUCTION OF BORON EPOXY PLATES SUBJECTED TO FATIGUE LOADING. T. K. O'Brien\*, and K. L. Reifsnider., Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Boron Epoxy laminates in a  $0^\circ; +45^\circ; -45^\circ; 0^\circ; 0^\circ; +45^\circ; -45^\circ; 0^\circ$  lay up were tested statically for initial strength and fracture strain and tested in strain controlled fatigue loading at 30 hertz,  $R = 0.1$ , for five different testing sequences.

A reduced stiffness analysis was used in conjunction with laminated plate theory to predict stiffness changes based on observed debonding and fiber breakage. Specimens used for strength analysis either fractured during fatigue or were loaded statically to failure after fatigue. All specimens were leached using a heated acid and fiber breakage was recorded.

A correlation is noted between debonding and stiffness changes and also between fiber breakage and strength reduction. (Aided by Air Force Office of Scientific Research Grant Number AFOSR 303487-1)

SIGNATURE ANALYSIS OF ACOUSTIC EMISSION FROM GRAPHITE/EPOXY COMPOSITES. S. Russell\* and E. G. Henneke, II, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Acoustic emissions have been monitored for crack extension across and parallel to the fibers in a single ply of graphite/epoxy composite. Spectrum analysis was performed on the transient signals to ascertain if the fracture mode could be characterized by a particular spectral pattern. The specimens were loaded to failure quasi-statically in a tensile machine. Visual observations were made via an optical microscope mounted on the crosshead so that the operating fracture mode could be correlated with the particular acoustic emission event. To date, the results indicate a tendency for fiber breakage to be characterized by a wider spectral bandwidth of the emission than longitudinal splitting. Additional work is proceeding to refine and further develop the experimental technique. (Supported by NASA Langley Research Center, Grant No. NSG 1238.)

A NOVEL EXPERIMENTAL ARRANGEMENT FOR TESTING OF ELECTRICAL BRUSHES. V. Srikrishnan\*, S. Dillich\* and D. Kuhlmann-Wilsdorf, Dept. of Mat. Sci., Univ. of Va., Charlottesville, VA 22901

The performance of available electric brushes puts a limitation on the development of high-speed/low-voltage motors or generators that would otherwise be technologically possible. Contact resistance as well as brush wear are of considerable concern. In order to permit the more efficient screening of the performance of test brushes in research to improve brushes, as also to simplify the investigation of the rotor wear, an apparatus has been developed that makes use of easily interchangeable inserts in a test rotor. The surfaces of such inserts are continuous with the cylindrical rotor surface on which the brushes are tested. The inserts are made of the candidate material, whether solid, or plated, or made with other specialized surface finishes. The contact resistance of the brushes relative to the insert material as compared to that of the rotor is monitored by oscilloscope. The wear damage can be studied optically or by SEM and/or via chemical tests, hardness measurements etc., on the inserts. Transmission electron microscopy and other destructive tests can be made similarly, thereby sacrificing only the rather small, easily made inserts instead of the whole rotor. As a further advantage, the inserts can be periodically examined to monitor the gradual changes taking place as the brush is "run-in" and as wear progresses.

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AN INVESTIGATION OF EDGE DAMAGE DEVELOPMENT IN QUASI-ISOTROPIC GRAPHITE/EPOXY LAMINATES. D. O. Stalnaker\*, W. W. Stinchcomb. Engineering Science & Mechanics Dept., Va. Polytechnic Institute and State Univ., Blacksburg, VA. 24061.

This investigation describes and documents in detail the initiation, growth, and interactions of damage along the free edges of two types of graphite/epoxy fiber-reinforced composite laminates. The damage is initiated by tensile static loading of flat coupons from each type to three different stress levels. Growth of the damage was caused by tension-tension fatigue loading. The laminates that were investigated differed only by stacking sequence.

The observations were made through the use of the replication technique, a method developed for the purpose of this investigation. This technique allows for three-dimensional, instantaneous recordings of the entire specimen edge while it is under maximum load. The recordings or impression can be studied microscopically and photographed. This method provides for detail and an overall field of vision that has not been obtained in previous studies.

An approximate stress analysis based on laminated plate theory and a more sophisticated finite element analysis were used to determine the stress distributions. A correlation was made between these stresses and the types of edge damage observed.

THE EFFECT OF SOLAR RADIATION AND FLIGHT SERVICE ON MOISTURE ABSORPTION IN RESIN MATRIX COMPOSITES. D. R. Tenney\*, J. Unnam\*, and S.S. Tompkins\* NASA Langley Research Center, Hampton, Va. 23665

The moisture absorption/desorption behavior of resin matrix composites exposed to commercial aircraft environments was mathematically modeled using weather data to define ground exposure conditions and aircraft utilization data to define typical flight scenarios. Solar radiation data together with cloud and wind information were included in the analysis to estimate effective temperature of composite panels during ground exposure. Calculations were performed for different panel surface properties (absorptivity, emissivity, heat transfer coefficient) to determine the sensitivity of moisture absorption to these properties. Small changes in these properties were found to cause significant changes in the amount of moisture absorbed. Results are presented for T300/5208 which indicate that a composite panel exposed to solar heating will pick up 20 to 30% less moisture than a panel exposed in the shade. Inclusion of an 8 hour day flight at 20,000 feet altitude results in an additional decrease of approximately 10%.

VISCOSITY OF AN ELASTOMER-MODIFIED EPOXY RESIN. Woodrow W. Wagner\*, Old Dominion University, Norfolk, VA 23508, and Howard L. Price, NASA-Langley Research Center, Hampton, VA 23665.

The viscosity of an elastomer-modified epoxy resin has been measured in steady shear flow at room temperature using the cone and plate mode on the Instron Rotary Rheometer. The viscosity of a widely used epoxy, a typical toughening elastomer, and a blend of the two was both non-Newtonian and time dependent. Non-Newtonian behavior was demonstrated by viscosity reduction at higher strain rates, with the exponent  $n$  in the two-parameter Oswald-de Wale (power law) model being less than unity. This pseudoplastic response is used to advantage in processing. Time dependent behavior was demonstrated by the change of viscosity with time at constant strain rate immediately after a step change in strain rate. If the step was from low to high rates, the viscosity decreased with time (thixotropic response). For a high to low rate step the viscosity increased with time (rheoplectic response). In either case the viscosity approached a constant value after several minutes. Such viscosity changes often are found in solid-liquid suspensions but rarely have been observed in polymers only. The time dependent behavior is interpreted in terms of the destruction and reformation of an as-yet-undefined polymer structure. (Work performed at NASA-LaRC; W. W. W. was supported by NASA Grant NGR 47-003-052.)

DIFFUSION IN DENTAL MATERIALS. H. Archie Werner\* and R. E. Barker, Jr., Dept. of Mat. Sci., Univ. of Va., Charlottesville, VA 22901

Mercury diffusion in dental materials is of considerable importance. In dental amalgam, for instance, mercury reacts with silver and tin to form the final product. The importance of Hg-diffusion in this case is fairly well documented.

Since a new selective interfacial amalgamation layer has been developed by Zardiackas and Stoner to prevent corrosion of dental amalgams, mercury diffusion through this layer is of interest because mercury plays a role in the bonding process.

The technique involves obtaining X-ray energy spectra (XES) from an X-ray energy analyzer coupled to a scanning electron microscope (SEM). By utilizing this technique, one can determine diffusion parameters with an accuracy of 10%-20%.



## Section of Medical Sciences

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GROWTH RATES AND TUMOR TAKES IN MICE WITH TRANSPLANTED TUMORS EXPOSED TO HALOMETHANES. B.A. Barrett\*, V.M. Sanders\*, J.F. Borzelleca, and A.E. Munson, Dept. of Pharm. MCV/VCU Cancer Ctr., Med. Col. of VA., Richmond, VA. 23298

The objective of these investigations is to determine if 2 organic water contaminants trichloromethane (CHCl<sub>3</sub>) and dichlorobromomethane (BrCHCl<sub>2</sub>) alter the growth rate and tumor take rate of 2 transplantable neoplasms. C<sub>3</sub>H and C57Bl/6 mice bearing a mammary carcinoma and the B16 melanoma respectively were exposed for 30 days by oral gavage to varying doses of CHCl<sub>3</sub> and BrCHCl<sub>2</sub>. Tumor takes were evaluated by inoculating mice with increasing numbers of tumor cells in the right hind glutemus muscle and after gavaging with vehicle, 50 mg/kg CHCl<sub>3</sub> or 12.5 mg/kg BrCHCl<sub>2</sub> the number of palpable tumors per group was determined 20, 30, 40, and 50 days later. The halomethanes did not decrease the number of tumor cells necessary to induce these neoplasms. Tumor growth rates were measured by giving 10<sup>5</sup> B16 melanoma cells and 5 x 10<sup>5</sup> C<sub>3</sub>H carcinoma cells gavaging for 30 days with various doses of CHCl<sub>3</sub> and BrCHCl<sub>2</sub> and measuring twice a week using a Venier Caliber. The halomethanes did not exhibit an effect on the growth rates of the two tumors. The mean lifespan of the C<sub>3</sub>H mice bearing a mammary carcinoma was 31.0±2.3 (S.E.) days for the C57Bl/6 naive bearing a B16 melanoma is 24.8±1.4 days. There was no significant change in lifespan of the animals exposed to the halomethanes. Supported by EPA Grant number R804701010.

LASER-ACTIVATED DETERMINATION OF HUMAN CELL DNA CONTENT. D. E. Berry\* and J. M. Collins. Dept. of Biochemistry and MCV/VCU Cancer Center, Med. Col. of Va., Richmond, Va. 23298

Determination of the DNA content of embryonic human lung fibroblasts grown in culture was accomplished by use of a two-parameter cell sorter. The beam of an argon ion laser was directed across the path of a jetstream of droplets containing the cells, previously fixed and stained with a fluorescent dye, propidium iodide, specific for DNA. The amount of fluorescence detected was thus linearly proportional to the amount of DNA contained in the cells. A multi-channel pulse-height analyzer accumulated and displayed the processed signals as pulse-amplitude frequency distribution histograms.

Two lines of cells were examined: normal WI-38 fibroblasts and their SV-40 transformants, VA-13. Laser-activated determinations of the DNA content of WI-38 cells revealed a large population in the G<sub>1</sub> phase of the cell cycle with a peak amount of fluorescence in channel 38 and a smaller population in the G<sub>2</sub> phase with a peak in channel 75. Similar determination of the amount of DNA in VA-13 cells revealed a large population of G<sub>1</sub> cells with a peak in channel 51 and a population of G<sub>2</sub> cells with a peak around channel 97. However, the electronically amplified signal from VA-13 cells was exactly twice as strong as from WI-38 cells, indicating that VA-13 cells contained slightly more than twice the amount of DNA found in WI-38 cells. (This work was supported by NIH grant CA 17177).

THE ACUTE TOXICITY OF THE HALOMETHANES: DRINKING WATER CONTAMINANTS. K.T. Brady\*, V. M. Sanders\*, J.F. Borzelleca, and A.E. Munson, Dept. of Pharmacology and MCV/VCU Cancer Center, Med. Col. of VA., Richmond, VA. 23298.

The acute toxicity of the following four organic water contaminants was determined: a) trichloromethane (CHCl<sub>3</sub>), b) bromodichloromethane (BrCHCl<sub>2</sub>), c) dibromochloromethane (Br<sub>2</sub>CHCl), and d) tribromomethane (Br<sub>3</sub>CH). Ten ICR Swiss male and female mice were gavaged at each dose level. The mice were observed for gross behavioral changes, death rates were documented over a 14 day period, and necropsies were performed on dead animals. The LD<sub>50</sub>'s (95% confidence limits) were CHCl<sub>3</sub> males 1120 (789-1590), females 1400 (1120-1680); BrCHCl<sub>2</sub> males 450 (326-621), females 900 (811-999); Br<sub>2</sub>CHCl males 800 (667-960) females 1200 (945-1524); Br<sub>3</sub>CH males 1400 (1205-1595), females 1550 (1165-2062). With all compounds death occurred up to nine days after administration. The target organs appeared to be the liver and kidney, with evidence of stress as shown by adrenal hemorrhage. Sedation and anesthesia was observed within an hour after gavaging with doses above 1000 mg/kg. The metabolism of CHCl<sub>3</sub> has been demonstrated to be dissimilar in different species, strains and sex. It appears from these studies that this sex difference is evidenced with other halomethanes as well. In all cases the males are more sensitive to the compound than the females. Supported by EPA grant R804701010.

SERUM VITAMIN A LEVELS IN NEONATES. R. B. Brandt, D. G. Mueller\*, J. R. Schroeder\*, and B. V. Kirkpatrick\*. Depts. of Biochemistry and Pediatrics, Med. Col. of Va., Va. Commonwealth Univ., Richmond, VA 23298

Hypovitaminosis A may be associated with mucous membrane disruption. The mucous membranes of the gastrointestinal tract of premature neonates show a high incidence of ulceration and necrosis in the disease, necrotizing enterocolitis (necr. ent.) associated with high mortality. As part of a preliminary study to assess a possible relationship between vitamin A (vit. A) and necr. ent., the serum levels of vit. A were determined by a specific spectrofluorometric method in premature or term neonates within the first 24 hrs after birth. Premature neonates (N = 42, 32 ± 0.4 weeks) had a serum vitamin A level (14.9 ± 0.98 µg/100 ml) significantly lower (p<0.001) than term neonates (N = 51, 22.4 ± 0.99 µg/100 ml). Linear regression analysis for serum vit. A vs gestational age showed no significant correlation. A significantly lower value in mean serum A was found for premature neonates at or before 34 weeks of gestation compared to 36 weeks. A linear correlation (p<0.05) was also found between serum vit. A and serum protein. Further investigation is in progress to investigate possible correlation between the lowered serum vit. A in premature neonates with necrotizing enterocolitis.

HIGH LEVEL OF INBREEDING IN A NATIVE VIRGINIA POPULATION. Robin J. Caldwell\*, J. Ives Townsend, and M. J. V. Smith\*. Department of Human Genetics and Division of Urology, MCV-VCU, Richmond, VA 23298.

Applying computer techniques to data from a large Virginia isolate, we analyzed inbreeding in the population and identified the common ancestors of people affected with rare autosomal recessive diseases. Methodological problems lead us to believe that our estimates of inbreeding coefficients (F) are very probably underestimates, although of the right order of magnitude. Inbreeding coefficients for individuals varied from 0 to 0.08, that is, to greater than the value for offspring of first cousin marriages. The mean for the whole population was 0.01154, which showed an average kinship closer than that of the offspring of second cousins once removed. Estimates by generations showed that inbreeding before 1900 was nearly twice as great as in the twentieth century. A single couple who married around 1890 was identified as the most recent common ancestors of all individuals affected with cystinuria. Another couple who married about 1895 was identified as the most recent common ancestors of two cousins affected with propionic acidemia.

INTERACTIONS OF THE MAJOR NUCLEAR ENVELOPE POLYPEPTIDES REVEALED BY DISULFIDE BOND FORMATION. D. L. Cochran and K. R. Shelton, Dept. of Biochemistry, Med. Col. of Va., Richmond, Virginia 23298

Covalent crosslinking can reveal interchain polypeptide associations that exist in membranes. Isolated avian erythrocyte nuclear envelope was reacted with a series of protein crosslinking reagents. Native interaction of polypeptides was assessed by electrophoresis of the polypeptides from reacted envelope on cylindrical and two-dimensional polyacrylamide gels containing sodium dodecyl sulfate. Certain stained bands, representing one or more polypeptides of the same molecular weight, diminished and disappeared while new bands of higher molecular weight appeared in a reciprocal fashion. The two predominant nuclear polypeptides in the isolated envelope were converted almost completely to polymeric species by oxidation of intrinsic sulfhydryl groups; presumably, interchain cystine bonds were formed. The major products are two dimeric species. Higher molecular weight species are also formed. In conjunction with protein solubility and distribution studies previously reported from this laboratory, this observation provides strong support for a model of nuclear structure wherein these polypeptides are involved in an oligomeric, proteinaceous nuclear skeleton. (Work supported by Grant number CA 15923, awarded by the National Cancer Institute, DHEW).

A METHOD FOR WEIGHTING TO ESTIMATE GENE FREQUENCIES IN INBRED POPULATIONS. D. L. Cragle\*, J. Ives Townsend, M. J. V. Smith\*, and W. E. Nance\*. Dept. of Human Genetics and Div. of Urology, MCV-VCU, Richmond, VA 23298.

In human population genetics, interest is often drawn to isolated populations that are rather small and so inbred that it is almost impossible to obtain a random sample to apply the Hardy-Weinberg equilibrium formula and estimate gene frequencies. Related individuals have, at some loci, genes that are identical by descent from common ancestors; a given gene may be counted repeatedly if all individuals are treated as though unrelated. Consequently, an estimate of gene frequency derived from a sample of related individuals will not have the same precision as one derived from the same number of unrelated cases. Thus, to estimate the frequencies of 23 alleles in nine blood group systems in an inbred Virginia population, it has been necessary to devise special statistical treatment of the observed data. Each person tested is paired with every other person tested and a weight determined for the pair according to the discrete type of kinship exhibited between the individuals in an extensive pedigree of the isolate. The weight is applied to the combined gene frequencies of the pair. This procedure reduces the bias caused by inbreeding, and permits one to estimate with greater precision the gene frequencies.

SYNAPTOGENESIS IN THE MAIN SENSORY TRIGEMINAL NUCLEUS OF THE RAT. H.C. Clark,\* Department of Anatomy, Medical College of Virginia, Richmond, Va. 23298

In the main sensory trigeminal nucleus of the rat, primary afferents from the trigeminal ganglion form the central elements of synaptic glomeruli and other large S vesicle axo-dendritic and axo-somatic synapses. Other sources, chiefly the spinal trigeminal nucleus, form small S vesicle and P vesicle synapses on dendrites, soma, and axo-axonic P vesicle synapses in the glomeruli. The unique synaptic specificity of this nucleus permits the analysis of sequential synaptic development. For this purpose fetal, neonatal, and adult rat nuclei were observed at the electron microscopic level. By the 18th day of gestation finger-like processes of primary afferents contact dendrites. At these contact sites, membrane densities appear before spherical vesicles are seen. Up to the 2nd postnatal day, synaptic development consists of increasing numbers of fine contacts and the enlargement of some presynaptic elements. From 2 to 6 days glomerulus formation begins and axo-somatic synapses appear. Axo-axonic synapses appear and initially contain spherical vesicles. From 8 to 10 days P vesicles appear in axo-axonic and axo-dendritic synapses. By the 14th day synaptic development appears complete.

SPECTROPHOTOMETRIC DETERMINATION OF BLOOD PLASMA LEVELS OF PROTEIN DETECTING HUMAN CANCER. G. Colmano, Dept. Veterinary Science, VPI & SU, Blacksburg, VA 24061

A spectrophotometric scan (185-650 nm) of blood plasma, optimally diluted with HOH, detected: 1. the 189 nm band of dipeptide bonds, ascribable to protein synthesis; 2. the 278 nm band subscribing the tryptophan, tyrosine, phenylalanine content of protein; 3. the 414 nm band of albumin-bound bilirubin, describing protein breakdown of erythrocytes; 4. the 610 nm absorbance that ratioed to the 278 nm absorbance of circulating protein indicated the Cu-ceruloplasmin-ACTH level of activity; and 5. the 630 nm absorbance that empirically had the best relation to the oxidation-reduction potential for the Fe-ascorbate-corticosterone level of activity. These absorbances and some of their ratios gave 13 variables for which the normal limits of each sample from a control group (no blood dyscrasia and no cancer) were taken to be the sample mean  $\pm$  2 standard deviation units. For each blood dyscrasia and for each cancer type the variables were declared out of the normal range if their assigned values exceeded the upper or lower defined normal limits. This analysis was processed to demonstrate that individuals with different blood dyscrasias and different forms of cancer were detectably different from non-blood dyscrasia and non-cancer control patients in one or more of the 13 variables used. The results indicated that different abnormalities in the variables were conducive to the identification of different pathological aspects of disease and indicated the direction for grouping patients with similar results for computer analysis.

POTENTIATION OF METHYLMERCURY TOXICITY BY PIPERONYL BUTOXIDE. L. R. Eaton\* and M. A. Friedman. Dept. of Pharmacology, Med. Col. of Va., Richmond, Va. 23298

Methyl-mercury (Me Hg) is an extremely potent neurotoxin about 25% of which is degraded *in vivo* to inorganic mercury. Piperonyl butoxide (PB) is a widely used pesticidal synergist which inhibits many mammalian detoxification reactions. The present study reports the effects of PB on MeHg toxicity. Groups of rats were fed diets containing 0, 20 or 40 ppm MeHg-Cl in combination with 0, 0.5 or 1% PB for periods up to 10 weeks. Body weight and neurotoxicity, expressed as "crossed hind legs" were recorded weekly. In a preliminary experiment with the high doses of PB and MeHg, PB induced a 12% decrease in mean survival time and a 20% decrease in mean latency time to neurotoxicity. The weight loss in PB-MeHg group was far greater than the control MeHg group. In a dose response experiment, mean survival times in rats fed 40 ppm MeHg-Cl were 5.75, 5.3, and 5.0 weeks at 0, .5, and 1% PB, respectively. By the ninth week 25% of rats fed 20 ppm MeHg-Cl showed neurotoxicity and 63% of the 0.5% PB fed showed neurotoxicity with some mortality. In experiments at 20 ppm MeHg-Cl both PB fed groups weighed considerably less than corresponding controls. (This research was supported by NIH Grant ES00701)



ON THE INTERACTION OF THE OTOLITHIC AND CUPULAR SENSATIONS. L. Ivan Epstein, Dept. of Biophysics, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298.

A differential equation is proposed for describing how the brain compromises between a sensation of rotation about a particular axis (derived from the semicircular canals) and a sensation of gravity perpendicular to this axis (derived from the otolith organs). It is shown that this differential equation, with suitably chosen and reasonable values of the parameters and initial conditions, will satisfactorily explain the experimental results of Lansberg, Guedry, and Graybiel (Aerospace Med. 36: 456-460, 1965).

INFLUENCE OF PIPERONYL BUTOXIDE ON THE MUTAGENICITY OF CHEMICAL CARCINOGENS. M.A. Friedman, Dept. of Pharmacology, Med. Col. of Va., Richmond, Va. 23298

Piperonyl butoxide (PB) is a pesticidal synergist which inhibits mammalian liver mixed function oxidase activity. Since the enzymatic activation of many chemical carcinogens to active mutagens may involve these enzymes, we tested the effects of PB on the mutagenicity of several carcinogens. In the case of dimethylnitrosamine, PB inhibited mutagenicity in the host mediated assay for periods up to 4 hrs. PB, also, inhibited dimethylnitrosamine mutagenicity in the dominant lethal test which reflects chromosomal changes rather than point mutations. PB, also, inhibited 3-methylcholanthrene mutagenicity in the dominant lethal test as well as in the Ames test (both *in vivo* and *in vitro*). PB had no effect on aflatoxin B<sub>1</sub> mutagenicity in the dominant lethal test but induced a 6 fold increase in mutagenicity in the Ames test. In the case of acetylaminofluorene, PB had no effect on mutagenicity in the dominant lethal test but inhibited mutagenicity in the Ames test. All effects in the Ames test were both dose and concentration dependent. (This research was supported by NIH Grant ES00701)

ACETYLCHOLINESTERASE ACTIVITY DETERMINATION IN VERTEBRATE NERVE TISSUE.

Wanda L. Holland\* and Fred C. Divers, Dept. of Life Sciences, Virginia State College, Petersburg, Virginia, 23803.

The acetylcholinesterase activity of tissue homogenates and extracts of vertebrate nerve tissue was determined using a photometric technique. The enzyme activity is measured by following the increase in yellow color produced from thiocholine when it reacts with dithiobisnitrobenzoate ions. The rate of color production is measured at 412 mμ in a spectrophotometer.

The rate of thiocholine production as a function of substrate concentration and enzyme concentration was determined. Values obtained were in close agreement with those found in the literature.

The effect of sodium phenobarbital on acetylcholine esterase activity was assessed using the above photometric technique. (Aided by NIH grant RR 08090-05).

A MORPHOLOGICAL STUDY OF NEURONAL ALTERATIONS IN CAT CEREBRAL CORTEX FOLLOWING GLOBAL ISCHEMIA. L.W. Jenkins, J.T. Povlishock\*, D.P. Becker\*, J.D. Miller\*, and H.G. Sullivan\*. Depts. of Anatomy and Neurological Surgery, Med. Col. of Va., Richmond, Va. 23298

Adult cats were subjected to total global ischemia via a ligation procedure. Following ischemia of 5 to 35 minutes duration the animals were perfused transcardially with aldehydes. Tissue samples from the sensorimotor cortex were processed for routine electron microscopy. In all ischemic insults, cortical neuronal alterations were observed. In insults of 5 minutes duration, ultrastructural examination demonstrated nucleolar condensation, alterations in chromatic patterns and particulate aggregations reminiscent of clumped interchromatic and perichromatic RNP granules. No cytoplasmic changes were observed. After 15 minutes of ischemia comparable changes were seen, however, occasional cytoplasmic changes reflected in the dilation of endoplasmic reticulum and the mitochondrial intracristal spaces were noted. With 35 minutes of ischemia, the nuclei showed increased chromatic and nucleolar condensation and a decreased number of RNP-like granule aggregates. Cytoplasmic changes revealed increased cytoplasmic volume, swollen mitochondria and dispersed endoplasmic reticulum and Golgi manifesting severe membrane disruption. On the basis of morphology alone, this data suggests that in acute ischemia those subcellular structures implicated in both RNA and protein synthesis are the first and most severely damaged. (Aided by NIH grant NS-12587).

EFFECT OF CHRONIC METHADONE ADMINISTRATION ON THE RAT ESTROUS CYCLE. J.H. Johnson\* and J.A. Rosecrans\*, Depts. of Anatomy and Pharmacology, Med. Col. of Va., Richmond, Va. 23298.

Methadone inhibits ovulation in the rat when administered during the critical period for neurogenic activation of pituitary LH release on the afternoon of proestrus. The present study was designed to test whether chronic administration of Methadone in the drinking water would have a similar effect. Female SD rats (Flow) were caged individually and allowed drinking water only between the hours of 17:00 and 08:00 daily. The drinking water contained 0.3 mg/ml Methadone HCl and the average daily ingestion was 30-35 ml resulting in a daily dose of approximately 40 mg/kg. The estrous cycle was followed by daily vaginal smears. The majority of rats showed regular estrous cycles, with a tendency toward a larger proportion of 5-day cycles during the period of Methadone treatment. Rats were ovariectomized on the morning of estrus and the ova contained within the oviducts were counted. Ovulation was checked in 8 groups of 4-5 rats, one group during each 5-day period between 5 and 45 days after the beginning of Methadone drinking. In each group up to 40 days at least 3 rats ovulated, and in the 40-45 day group 2 of 5 ovulated. These results indicate that a chronic daily administration of Methadone to female rats does not prevent the occurrence of estrous cycles and ovulation, and therefore would not be inconsistent with normal reproductive function. (Supported by NIH Grant DA 00296)

STUDIES ON INFECTION STONES. W. E. Keefe, Department of Microbiology, Medical College of Virginia, Richmond, VA 23298

Preliminary *in vitro* experiments have been performed to determine the synergistic effects of ethylenediamine tetraacetic acid, hydroxyurea, and nitrofurantoin in preventing the formation of struvite crystals and/or the growth of *Proteus mirabilis* in urine.



CHANGES IN ARCULATE NUCLEUS ELECTRICAL ACTIVITY INDUCED BY NOREPINEPHRINE (NE) AND LUTEINIZING HORMONE RELEASING HORMONE (LHRH). Richard J. Krieg, Jr. and Charles H. Sawyer\*, Departments of Anatomy, Medical College of Virginia-VCU and University of California, Los Angeles.

In the spontaneously ovulating female rat, a preovulatory surge of luteinizing hormone (LH) occurs on the afternoon of proestrus. NE has previously been shown to stimulate LH release in the ovariectomized, steroid primed rat, probably by inducing LHRH secretion (Endocrinology 99:411, 1976). The present study was designed to investigate the effects of LHRH and NE on the arcuate nucleus, an hypothalamic structure important to the control of LH secretion. Under urethane anesthesia, saline control vehicle, LHRH, and then NE were sequentially infused into the third ventricle. Sixty minutes elapsed between saline and LHRH infusions, and 2½-3 hours between LHRH and NE. Arcuate nucleus spike activity was recorded using multiunit electrodes and amplitude discriminating circuitry. While LHRH induced a marked increase in arcuate nucleus spike activity, NE caused a characteristic decrease. Since arcuate nucleus activity is decreased by a stimulus which has been shown to cause LH release (NE), and is accelerated by LHRH which is likely to be acting as a mediator of ultra-short loop feedback, we suggest that some elements of the arcuate nucleus might be inhibitory to LH release. These elements may be the tuberoinfundibular dopaminergic neurons. (Supported by a grant from NIH (NS01162) and an A. D. Williams Fellowship from MGV-VCU).

HELIX STRUCTURAL FEATURES OF YEAST 5.8 S rRNA. D. R. Lightfoot, Dept. of Biochem. and Nutr., Va. Polytechnic Inst., Blacksburg, Va. 24061

The large subunit of yeast ribosomes contains two small rRNAs, 5 S and 5.8 S, the latter having been not yet characterized for its secondary, double helix structure. 5.8 S rRNA was isolated from baker's yeast by the hot phenol, SDS method and was characterized as pure by its size, spectral properties, and T<sub>1</sub> ribonuclease fingerprint. High resolution ultraviolet absorption melting profiles for 5.8 S rRNA were collected as a function of salt concentration, RNA concentration, and thermal dispersion, and absorption spectra were collected at several temperatures. The data suggested several classes of helices of different size and G + C composition melting at increasing temperatures. These data were compared to a secondary structural model predicted by consideration of all possible helical stretches, calculated Gibbs free energy of each stretch, and a pattern of molecular folding. Data were also compared with other proposed models for 5.8 S rRNA. The melting analyses identified 3 to 5 separate melting components by their numbers of base pairs, G + C content, and relative thermodynamic stability. These data correspond well with components of the author's predicted 5.8 S rRNA model but do not exclude models proposed by others.

DECREASED WHOLE BLOOD LUTEINIZING HORMONE IN OVARECTOMIZED RATS AFTER MICROINJECTION OF MORPHINE AND METHADONE INTO MIDBRAIN RAPHE. G. Maughan\*, J.H. Johnson\* and J.A. Rosecrans\*, Depts. of Anatomy and Pharmacology, Medical College of Virginia, Richmond, Virginia 23298.

Systemically injected morphine blocks the surge of LH secretion essential for ovulation (Sawyer *et al.* 1955). This experiment was designed to test whether the tonic hypersecretion of LH in ovariectomized rats can be similarly blocked, and if so whether the effect can be localized to the midbrain raphe. Morphine (10µg) or methadone (20µg) was injected intracranially into ovariectomized rats through a cannula chronically implanted in either the dorsal or medial raphe nucleus. These locations are known to contain both opiate receptors and the potential to inhibit LH release. Duplicate 50µl blood samples were taken through an indwelling atrial cannula at 10-minute intervals for a period of 60 minutes before and 60 minutes after injection of the drug in 0.5µl of saline. Whole blood samples were assayed by double antibody radioimmunoassay and the results were expressed as ng NIH LH RP-1 per ml of whole blood. Mean LH levels were compared for pre- and post-drug periods in 17 experiments in 11 animals. A significant decrease in post-drug mean values was seen with both methadone (p<.01) and morphine (p<.05) injections. These results indicate that the neural mechanism regulating tonic LH secretion is susceptible to inhibition by narcotics, and that this effect may be mediated through the midbrain raphe. (Supported by NIH Grant DA 00296)

A TRANSMISSION AND SCANNING ELECTRON MICROSCOPY STUDY OF THE RELATIONSHIP OF T-TUBULES TO THE NUCLEAR ENVELOPE OF DOG MYOCARDIUM. R.D. LANE\*, R.S. CRISMAN\*, L.J.A. DIDIO\*, R. JOHNSON\*, Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23219 and Med. Col. of Oh., Toledo, Oh. 43614

Nuclear envelope invaginations have been described for smooth muscle, skeletal muscle, and cardiac muscle. These invaginations occur when the muscle cell is in the contracted state and their positions on the nuclear envelope generally correspond to the Z lines of adjacent myofibrils. One theory which has been proposed to account for these invaginations states that structural connections are present between the nuclear envelope and the myofibrils. These connections are postulated to induce the folding of the nuclear envelope during muscle contraction.

In this study, specimens of dog myocardium were processed for SEM using a ethanol cryofracture technique to expose intracellular structures. Examination of these specimens revealed T Tubules spanning from the Myofibrils across the perinuclear space to make contact with the nuclear envelope. In general these connections were located in the troughs of the nuclear invaginations. To substantiate this observation specimens were prepared for TEM. Lanthanum nitrate was used as a stain to identify the T Tubules within the muscle cells. The observations made on TEM specimens support the evidence from the examination of the SEM specimens that T Tubules play a role in the structural connections between the nuclear envelope and the myofibrils.

EFFECTS OF CHLOROPROMAZINE AND HALOPERIDOL ON DELAYED TYPE HYPERSENSITIVITY RESPONSE IN MICE. T.C. Markello\*, L.S. Harris, S.H. Smith\*, and A.E. Munson, Dept. of Pharmacology and MCV/VCU Can. Ctr., Med. Col. of VA., Richmond, VA. 23298

Chlorpromazine and haloperidol represent 2 classes of antidepressant drugs which are employed for a variety of psychiatric illnesses. The objective of this study was to assess the potential effects of these agents on the cell mediated immunity. Delayed type hypersensitivity (DTH) response to sheep erythrocytes (sRBC) was employed. CDF<sub>1</sub> male mice were sensitized with 10<sup>5</sup> sRBC i.v. and the antidepressant drugs and flumethazone (positive control) were administered s.c. on days 0-3 at doses of 5-50 mg/kg. On days 4 and 5 after sensitization the left hind footpad was challenged with 10<sup>8</sup> sRBC and footpad swelling measured 30 hr later by comparing the amount of <sup>125</sup>I albumin extravagation into the extravascular space of both hind feet. Chlorpromazine inhibited the DTH response by 100, 65, 50, and 25% at 50, 25, 10 and 5 mg/kg respectively on day 4. Haloperidol suppressed the DTH response 100, 72, 47 and 21% at 50, 25, 10 and 5 mg/kg respectively on day 4. The expressed response was not mediated via anti-inflammatory activity because these agents did not possess activity in the carrageenan footpad swelling assay while administered in the same regimen. However, when these agents were administered 30' prior to carrageenan, they did exhibit pronounced antiinflammatory activity. Supported in part by USPH grant DA 01312.

SUBCELLULAR FRACTIONS OF LOBSTER NERVOUS TISSUE. R.F. Newkirk, J.L. Jones\* and W.S. Grizzard, Jr.\*, Dept. of Life Sciences, Virginia State College, Petersburg, Va. 23803.

Newkirk *et al.* (1976) first reported synaptosome formation from lobster nervous tissue. Their analysis of the mitochondrial marker fumarase showed its activity to be low as compared Dowdall and Whittaker's (1973) results from the squid (85% less). The lobster data was based on a limited number of experiments (2) and showed considerable variation in the activity recovered.

Results of this study confirm the previous findings of low fumarase activity in the lobster and further showed that considerably less variation in the recovered activity results when the assay is run at 20-25 °C instead of 0-4°C. This study also demonstrated that the use of cytochrome c as a mitochondrial marker resulted in a higher level of activity than fumarase (0.51 units/gram tissue and 0.21 units/gram tissue respectively). Although its activity is low compared with fumarase in the squid (0.51 units/gram tissue and 1.9 units/gram tissue respectively) cytochrome c yielded data consistent with the fumarase results. Thus it was concluded that cytochrome c is an acceptable alternative mitochondrial marker for lobster nervous tissue. (Supported by NIH grant RR-08090-04).



STRUCTURAL IMPLICATION OF NON-HISTONE NUCLEAR PROTEIN PHOSPHORYLATION. S. Offenbacher\* and E. S. Kline, Dept. of Biochemistry, Med. Col. of Va., Richmond, Va. 23298

Studies using an *in vitro* incubation system for the incorporation of  $^{32}\text{P}$  into rat liver nuclear non-histone proteins (NHP) have provided kinetic and structural data regarding the phosphorylation of these nuclear proteins. After two hours of incubation, the phosphorylated species of NHP which are labeled are predominantly the lower molecular weight NHP. At longer incubation times more of the  $^{32}\text{P}$  is found in the heavier NHP species and, concomitantly, there is a loss of  $^{32}\text{P}$  from the lower molecular weight NHP species. The phosphate bonds of the NHP are alkaline phosphatase labile, and following acid hydrolysis, have been shown to reside primarily in esterified serine and threonine residues. Alkaline phosphatase treatment changes the molecular weight distribution of the NHP; decreasing the higher molecular weight species, and increasing the lower molecular weight species. Following alkaline hydrolysis of  $^{32}\text{P}$  labeled NHP, which was carried out to prevent the cleavage of phosphodiester bonds, a  $^{32}\text{P}$  labeled compound was isolated. The chromatographic and chemical data collected to date suggest the identity of this  $^{32}\text{P}$  phosphate-containing compound to be polyphosphate. Although the existence of polyphosphate has been demonstrated previously in rat liver nuclei, its function has not been ascertained. In this work a structural relationship between polyphosphate and NHP is proposed.

DNA SYNTHESIS STIMULATION AND INHIBITION IN PROLIFERATING EPIDERMAL AND DERMAL CELLS. S. Rothberg, G. E. Nancarrow\*, V. L. Church\*, Dept. of Dermatology, Med. Col. of Va., V.C.U., Richmond, Va. 23298

Previous results indicate a lag period of 12-28 hrs between epidermal stripping and *in vivo* response; stimulation of thymidine incorporation into epidermal (E) and dermal (D) DNA. The signal resulting from E stripping which translates into an intracellular signal that stimulates DNA synthesis, was investigated by *in vitro* experiments. Similar results, stimulation of DNA synthesis, were observed as for *in vivo* experiments.

Signal interference was detected when the skin was preincubated in Cytochalasin B (CB) ( $10^{-5}\text{M}$ ) for  $\frac{1}{2}$  hr at the beginning of the lag period. Stimulation of thymidine incorporation into both E and DDNA was found after the lag phase period in proliferating cells of both control and stripped skin. Autoradiography of experimental sections indicated increased cellular labeling of the proliferative cells influenced by the preincubation in CB for control epidermis.

Signal interference results in an inhibition by other compounds (trypsin, colcemid, cycloheximide) which are known to influence surface receptor sites, microfilament or microtubular structure, or protein synthesis was found after testing these compounds in a similar manner. The results suggest that each of these compounds can alter or intercept the stimuli signal and cause stimulation or inhibition of the signal for DNA synthesis. (Supported by NIAMDD Grant 15285).

PREOPTIC ELECTRICAL STIMULATION IN THE RAT: INFLUENCE OF STIMULUS PARAMETERS ON LUTEINIZING HORMONE (LH) RELEASE. G.J. Somori\* and J.H. Johnson\*. Dept. of Anatomy, Med. Col. of Va. Richmond, Va. 23298.

Female CD rats were given 38 mg/kg pentobarbital on proestrus to block spontaneous ovulation. Electrical stimulation of the brain was done using a bipolar platinum electrode to deliver biphasic rectangular stimulus pulses of 1.5 mA, 1.5 msec, 15 Hz, 30 sec on/off for 60 minutes to the medial preoptic area of the hypothalamus. Stimulus parameter effect on LH release was studied by varying one of each of these parameters by a constant amount in 7 groups of rats. LH levels were determined by double antibody radioimmunoassay of blood samples taken from a jugular cannula immediately before and at frequent intervals up to 2 1/2 hours after start of the stimulation. Stimulation induced LH release and ovulation with each set of parameters tested. Significant increase in plasma LH was observed in most animals after 20 minutes of stimulation. Peak LH levels occurred at the end of the stimulation period, with a rapid decline to prestimulation levels by 150 minutes after start of the stimulation. A direct relationship was observed between height of the LH peak and number of ova counted on the morning following brain stimulation. These results indicate that brain-pituitary control mechanisms respond rapidly to electrical stimulation, and remain active throughout the stimulation. Furthermore, at the levels of frequency, current, and time used, no single parameter was critical to the induction of LH release and ovulation. (Aided by NIH Grant HD07749)

MODIFYING EFFECTS OF AMINOGLUTETHIMIDE ON 1-DECANOL INDUCED EPIDERMAL HYPERPLASIA. Audrey F. Redmond\* and Simon Rothberg, Dept. of Dermatology, Med. Col. of Va., V.C.U., Richmond, Va. 23298

Although the biochemical role of arginase in epidermal metabolism is unknown, elevated arginase activity is associated with epidermal hyperplasia and hyperkeratinization. Epidermal hyperplasia was induced experimentally by topical application of 1-decanol to one side of the hairless mouse. The other side served as control. Incorporation of TdR into DNA was depressed 6 hrs and elevated on days 1 and 2 after decanol. DNA content was depressed on day 1 and elevated on day 3. Epidermal arginase was elevated on days 2-7 after decanol with peak activity on day 3. In order to study how adrenal corticoid deprivation relates to biochemical events associated with hyperplasia, additional mice were injected 1 hr prior to decanol application with aminoglutethimide phosphate (AG), an inhibitor of adrenal steroidogenesis. Incorporation of TdR into DNA was unaltered by AG pretreatment, but DNA content was not elevated on day 3. Also, with AG pretreatment, peak arginase activity occurred on day 4 and was near control level by day 5. The results suggest that topical application of decanol to the hairless mouse induces epidermal hyperplasia with subsequent induction of arginase activity. Alteration of adrenal corticoid biosynthesis delays the sequence of cellular events associated with this hyperplasia. (Supported by USPHS, NIAMDD Research Fellowship AM05068 and Grant 15285.)

A TRACE ELEMENTAL SURVEY OF ANCIENT SAMPLES: ARSENIC, SELENIUM, LEAD, IRON, CADMIUM. Joseph J. Saady, Dept. of Clinical Pathology, Med. Col. of Va., Box 696, Richmond, Va. 23298.

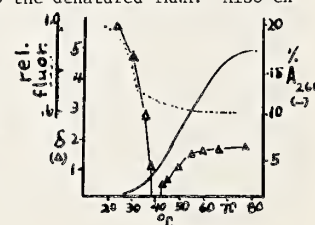
The effect of trace elements on our environment as well as on man and his health, has long been a topic of interest. More recently these relationships have caused even more discussion and controversy due to the increased interest in cancer and the implication of trace elements (particularly trace metals).

Man is continually changing his environment and it is important to document these changes, if any, and observe trends. This study offers a unique opportunity to go back into history and measure and record baseline elemental levels (As, Se, Pb, Fe, Cd) in certain food stuffs, which were buried with the ancient Peruvians as much as two thousand years ago. These levels can then be compared to modern day levels.

CORRELATION OF STRUCTURAL CHANGES OF TRANSFER RNA DURING MELTING WITH CHANGES IN TRANSIENT ELECTRIC BIREFRINGENCE. M.R. Thompson and C.H.O'Neal, Dept. of Biophysics, Med. Col. of Va., Richmond, Va. 23298

Bulk yeast and liver tRNA and purified phe tRNA were examined by transient electric birefringence during a melting experiment. Polyacrylamide gel electrophoresis was used before and after to monitor the integrity of the nucleic acid. Between 20°C and 35°C a dramatic drop in birefringence ( $\delta$ ) occurred with an increase in size of the molecule. This change in tRNA structure was also observed at similar temperatures with acridine conjugates of tRNA by Millar and Steiner (Biochem. 5, 2289, 1966). Examination of the hyperchromicity curve shows only a few hydrogen bonds have been broken during this temperature range. Between 40°C and 60°C another birefringent species of opposite sign appears which would most probably be due to the denatured tRNA. Also examined were the effects of charging,  $\text{Mg}^{++}$  conc., dialysis and denaturants. The above changes will be discussed in reference to the phe tRNA structures presented at the 1976 EMBO Workshop on tRNA by Rich and the group of Clark and Klug.

Supported by NSF Grant GB 14046.



EFFECTS OF AFLATOXIN ADMINISTERED SUBACUTELY ON HAMSTER LIVER MIXED FUNCTION OXIDASE ACTIVITY. A.N. Tucker\*, T. Tang, and M.A. Friedman. Dept. of Pharmacology and Dept. of Microbiology and MCV/VCU Cancer Center, Med. Col. of Va., Richmond, Va. 23298

The effect of the mycotoxin aflatoxin B<sub>1</sub> on hepatic microsomal mixed function oxidase in hamsters was studied using a dose of 1 mg/kg administered daily for 3 to 8 days, or 3 times a week for 7 weeks by i.p. injection. In all cases a loss of microsomal protein and cytochrome P-450 was noted. The decrease in microsomal enzyme activities (aminopyrine demethylase, aniline hydroxylase, and biphenyl-4-hydroxylase) paralleled the loss of cytochrome P-450. Microsomes from hamsters treated for 7 days failed to exhibit a typical type I binding spectrum with aminopyrine. The presence of the insecticide synergist piperonyl butoxide in the diet prevented the effects of aflatoxin on the mixed function oxidase system in the chronic studies, suggesting that metabolism of aflatoxin is essential for its effect on liver microsomal function.

Homogenates from hamsters treated for 7 days with aflatoxin showed decreased ability to activate a wide range of test carcinogens in the Ames test. In contrast, when aflatoxin B<sub>1</sub> itself was used as test mutagen, the homogenates from aflatoxin B<sub>1</sub> treated animals were able to activate it to the same extent as homogenates from control animals. (Supported by NIH Grant ES00701 and NIH Postdoctoral Fellowship 1F32CA05745)

INDUCTION OF LIVER ENZYMES BY NATURALLY OCCURRING CANNABINOID. J.M. Wrenn\* and M.A. Friedman, Dept. of Pharmacology and MCV/VCU Cancer Center, Med. Col. of Va., Richmond, Va. 23298

The present study characterizes the effects of naturally occurring cannabinoid compounds on tyrosine aminotransferase activity (TAT) in rodent liver. Both  $\Delta^8$ -tetrahydrocannabinol ( $\Delta^8$ -THC; 12.5-200 mg/kg, i.p.) and  $\Delta^9$ -tetrahydrocannabinol ( $\Delta^9$ -THC; 50-400 mg/kg, i.p.) produced dose dependent stimulations of TAT activity in mice when given 12 hr. before sacrifice. When mice were injected with  $\Delta^8$ -THC or  $\Delta^9$ -THC at a dose of 25 mg/kg, i.p. twice weekly for 4½ weeks basal TAT activity increased 1.9 fold and 1.3 fold, respectively, as compared to solvent control. An 8 week pretreatment with 3, 10, and 30 mg/kg  $\Delta^8$ -THC and  $\Delta^9$ -THC p.o. twice weekly resulted in a dose dependent stimulation of basal TAT activity at the two higher  $\Delta^8$ -THC doses. At 10 and 30 mg/kg  $\Delta^9$ -THC, a 1.3 fold increase of basal TAT activity was observed. Treatment of mice with cannabidiol (CBD 200 mg/kg, i.p.) produced a 2.1 fold stimulation of TAT activity in 6 hrs. However, cannabidiol (CBN 200 mg/kg, i.p.) increased TAT activity by only 1.2 fold, as compared to solvent control.  $\Delta^8$ -THC and  $\Delta^9$ -THC also produced a 2.2 and 2.7 fold increase, respectively, in basal TAT activity in adrenalectomized Sprague Dawley rats 6 hr after administration. (Supported by NIH Grants DA01248 and DA00490 and NIH Predoctoral Training Grant DA07027)

## Section of Microbiology

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

CYTOPATHIC EFFECTS AND CHARACTERIZATION OF DUCK PLAGUE HERPES VIRUS IN CELL CULTURE. R. Attanasio\* and J. C. Johnson. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Duck plague is a hemorrhagic, necrotic disease affecting the family Anatidae. The etiological agent has been reported to be a herpes-like virus. The Holland strain of duck plague virus (ATCC VR #684) induced perinuclear vacuolation 18 hours after infection when cultured in low passage number Pekin duck embryo fibroblasts, chicken embryo fibroblasts, and the duck fibroblast cell line (CCL-141). Within 48 hours infected cells lysed. Human (HeLa, HEP-2) and monkey (MK-2) cells were not affected. A simple, accurate plaque assay has been developed for the titration of this virus. Under conditions of the assay one-hit kinetics were observed, and the number of plaques produced was proportional to the virus concentration over a 2.6 log range. Macroscopically visible plaques (3mm dia.) appeared 5 days after infection. We have demonstrated that duck plague virus-induced cell culture cytopathic effect was inhibited by phosphonoacetic acid (PAA). In cultured duck embryo cells PAA concentrations up to 200 ug/ml did not induce cytopathic effect nor did it appear to reduce the growth of normal cells. Phosphonoacetic acid at concentrations as low as 60 ug/ml totally suppressed virus-induced plaque formation in duck cells.

CHARACTERIZATION OF MANNITOL DEHYDROGENASE IN PSEUDOMONAS AERUGINOSA. G. R. Bryson\*, S. M. McCowen and P. V. Phibbs, Jr., Virginia Commonwealth University, Richmond, VA 23284.

In *P. aeruginosa* PAO, mannitol enters the cells unaltered and is oxidized to fructose by inducible NAD-dependent mannitol dehydrogenase (MDH). Maximum specific activity of MDH was detected in extracts of cells cultured with mannitol as sole source of carbon. MDH activity was in the soluble (105,000 g supernatant) fraction of cell extracts and was concentrated by precipitation with 35-60% saturated (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>. The enzyme has a molecular weight of approximately 85,000 daltons, as estimated by Sephadex G-200 column chromatography. The enzyme was reactive with either mannitol or sorbitol, although mannitol was the preferred substrate with NAD serving as electron acceptor. 3-Acetyl-NAD was a poor electron acceptor and little activity occurred with NADP. The enzyme exhibited an apparent Km for mannitol of 5.1 mM and for NAD of 0.14 mM. MDH catalyzed the NADH-dependent reduction of fructose (apparent Km = 33 mM) with a Vmax twice that observed for the mannitol oxidation reaction. A single zone of MDH activity was observed when the enzyme was assayed following polyacrylamide disc gel electrophoresis. This zone of activity was not detected in electropherograms of mannitol-negative mutant strain (PFB 105) that contained no other demonstrable enzyme deficiencies.



VIRULENCE OF *NAEGLERIA FOWLERI* FOR MICE INOCULATED INTRAVENOUSLY. R. M. Haggerty\* and D. T. John. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, VA 23298

*Naegleria fowleri* is an ameboflagellate which causes fatal meningoencephalitis in man and laboratory animals. The following were examined for their effect upon the virulence of *N. fowleri* for mice: (1) culture agitation, (2) culture age, (3) incubation temperature, and (4) strain of parasite. Male DUB/ICR mice weighing 13-18 g were inoculated intravenously; there were 20 mice/treatment group. Cultures were incubated 72 h at 37 C unless stated otherwise. Amebae ( $2.5 \times 10^6$ /mouse) from agitated and unagitated cultures of *N. fowleri* (LEE) produced 80% and 45% mortality, respectively. Amebae ( $5 \times 10^6$ /mouse) harvested at five different points during the growth curve produced 45% mortality at 24 h, 80% at 48 h, 75% at 72 h, 55% at 96 h, and 25% at 120 h. Amebae ( $5 \times 10^6$ /mouse) incubated at different temperatures produced 55% mortality for 23 C, 100% for 30 C and 37 C, and 25% for 44 C. Mortality ranged from 40-100% for mice inoculated with  $2.5 \times 10^6$  amebae/mouse from cultures of 10 strains of *N. fowleri*. A 3-fold reduction in inoculum for the 6 strains producing 100% mortality resulted in mortality ranging from 30-95%. These results indicate that factors affecting the virulence of *N. fowleri* for mice may also influence the outcome of natural exposure and infection in man.

BACTERIOCIN TYPING AND SEROLOGICAL TYPING OF CLINICAL ISOLATES OF *PSEUDOMONAS AERUGINOSA*. P.H. Huley\* and H. P. Dalton. Dept. of Pathology, Virginia Commonwealth University, Richmond, VA. 23298

A total of 184 strains of *Pseudomonas aeruginosa* from clinical specimens submitted to four microbiology laboratories were studied. Using the Difco antisera set, 69% of the strains were typable. Types 1, 6, 11, and 10 were found most frequently. Pyocin typing, performed using the ALA 18 indicator strains and a chloroform lysate, yielded 92% typable strains. Combined pyocin and serological typing yielded 97% typable strains. Serological typing was found to leave too many strains nontypable. Pyocin typing suffered from lack of reproducibility both on a day-to-day basis and with same-day typing but did result in greater strain differentiation. A relationship between pyocin type and serological type was observed. Strains of the same serological type frequently had the same or similar pyocin type even when collected from geographically distinct locations. More than one sero-pyocin type were found infecting single patients. Antibigrams were not found to be discriminatory enough for use in strain differentiation. Cross infection, especially in the burn unit is suggested by the data. Sero-typing is recommended for routine use with isolates from particular areas of the hospital. Pyocin typing should be reserved for use in the even a possible nosocomial outbreak is indicated.

HUMORAL AND CELL-MEDIATED IMMUNE RESPONSIVENESS DURING GROWTH OF THE LEWIS LUNG CARCINOMA. Paal Klykken\*, Virginia M. Sanders\*, and Albert E. Munson, Dept. of Pharmacology and MCV/VCU Cancer Center, Med. Co. of Va., Richmond, VA. 23298

This study assessed the antibody forming capacity of BDF<sub>1</sub> male mice bearing the Lewis lung carcinoma (LLC) and described the host cells residing in the tumor. Thirteen days after inoculation of  $2 \times 10^6$  viable LLC cells the primary tumor weighed  $2.74 \pm 0.10$  g. Half the animals had the primary tumor excised by amputation. All tumor bearing mice succumbed within 33 days of pulmonary metastasis. The hemolytic plaque assay was employed to determine the number of IgM antibody forming cells (PFC) to sheep erythrocytes. PFC/ $10^6$  spleen cells and PFC/spleen  $\times 10^{-3}$  in non-tumor bearing mice were  $828 \pm 39$  and  $112 \pm 7$  (N=34) respectively. Seven days after tumor inoculation PFC/spleen was reduced to  $20 \pm 4$  and by day 27 no antibody response was detected in primary tumor bearing mice. In contrast PFC/spleen in the amputated group increased to  $92 \pm 13$  (N=16) on day 15 returning to non-tumor values by day 21. Flow micro-fluorometric analysis of the diploid cells yielded the following differential: 42% granulocytes, 35% monocytes, and 6% lymphocytes. Lewis lung chromosomal analysis gave a chromosome number between 66-77. These studies indicate that the primary tumor renders the host immunologically deficient and that the tumor possesses immune host cells. Supported by grants CA1755, CA1312, and DA00509.

STUDIES OF THE GENETIC BASIS OF EXOPOLYSACCHARIDE PRODUCTION IN *PSEUDOMONAS AERUGINOSA*. S.M. Markowitz\*, F.L. Macrina, and P.V. Phibbs, Jr., Depts. of Med. and Microbiology, Med. Col. of Va., Richmond, VA., 23298.

Chronic *Pseudomonas aeruginosa* infections are common in cystic fibrosis patients, and in most instances are caused by strains producing a unique exopolysaccharide capsule composed of alginate acid. These strains produce mucoid colonies on solid media; however, an irreversible loss of the mucoid trait occurs at a low frequency on subculture. Since the presence of alginate appears related to virulence we're attempting to explore the genetic basis of alginate biosynthesis by utilizing a conjugal transfer system featuring the broad host range plasmid RP1 (a P group plasmid conferring resistance to carbenicillin, tetracycline, kanamycin, and neomycin). A strain of *P. aeruginosa* containing RP1 was mated with each of 4 pairs of isogenic mucoid and non-mucoid clinical isolates and the frequency of R plasmid transfer determined. Such frequencies ranged from  $1 \times 10^{-3}$  to  $< 1 \times 10^{-9}$ , and was reproducible for each strain tested. The presence of exopolysaccharide did not consistently prevent or decrease plasmid transfer. One mucoid strain and its non-mucoid revertant were able to donate RP1 to a suitable recipient. All strains harboring RP1 were sensitive to lysis by the donor specific phage, PRRL. We conclude (1) that these strains are able to act not only as genetic recipients but also as genetic donors, and (2) that by exploiting the conjugative nature of the RP1 plasmid, manipulation of the genes for alginate biosynthesis may be possible.

EVIDENCE FOR MULTIPLE FRUCTOSE CATABOLIC PATHWAYS IN *PSEUDOMONAS AERUGINOSA*. S. M. McCowen, C. G. McNamee\*, and P. V. Phibbs, Jr. Departments of Microbiology and Biology, Va. Commonwealth Univ., Richmond, VA 23298

The soluble fraction of cell extracts of *P. aeruginosa* PAO contained an ATP-dependent fructokinase (fructose-6-P forming) when cells were cultured with mannitol as sole source of carbon. Fructokinase (FK) was not induced in cells grown on fructose, glucose or succinate. Mannitol-negative mutant strains deficient in mannitol transport and/or mannitol dehydrogenase (MDH) activities cannot oxidize mannitol to fructose; however, mannitol elicited full induction of FK in these strains. Mannitol appears to serve as the natural inducer for FK since fructose failed to cause induction in both wild-type and MDH-deficient strains. Mutant strains deficient in either phosphoglucose isomerase (PGI) or glucose-6-P dehydrogenase (G6PDH) failed to grow with mannitol as sole C source but retained the ability to grow at reduced rates on exogenously supplied fructose. Therefore, FK, PGI and G6PDH appear to be essential for catabolism of fructose generated endogenously by mannitol oxidation. In contrast, none of these enzyme are required for growth on exogenously supplied fructose that must be catabolized by an alternate pathway in *P. aeruginosa*.

ENHANCED ACTIVITIES OF LYSOSOMAL ENZYMES OF CULTURED VERO MONKEY KIDNEY CELLS TREATED WITH BACTERIAL LIPOPOLYSACCHARIDE. A. McGivney\* and S. G. Bradley, Virginia Commonwealth University, Richmond, Virginia 23298

The cellular bases for the toxicity of bacterial lipopolysaccharide (LPS) are not known. In fact, direct effects of LPS on cells have been established definitively only recently. We have examined the effect of LPS on the activities of selected lysosomal enzymes of African green monkey (Vero) kidney cells in continuous culture. A Westphal preparation of *Escherichia coli* 0127:B8 LPS, at 10 µg/ml, caused a two-fold increase within 4 h in the specific activity of β-glucuronidase or acid phosphatase in a granular fraction of homogenates of Vero cells. The increase in lysosomal enzyme activity was progressive with time for 8 h, occurred in a glucose-inorganic salts medium lacking serum or added growth factors, was inhibited by 5 µg cycloheximide/ml and was inhibited by 0.1 µg actinomycin D/ml. LPS did not alter the activity of catalase in fractions of homogenates of Vero cells. The increase in specific activities of β-glucuronidase and acid phosphatase was greater in the large granular fraction (which contains lysosomes and mitochondria) than in the supernatant fraction (which contains microsomes and soluble material). These observations, along with previous results, may indicate that enhanced lysosomal enzyme activity is the primary mechanism of action of LPS.



ANTIBODY LEVELS TO INFLUENZA VIRUSES IN SELECTED SWINE POPULATIONS. D.J. Merchant, H.A. Snyder†, W.D. Johnson\* and C.M.G. Buttery† Dept. of Microbiology and Immunology and Div. of Community Medicine, Dept. of Family Practice, Eastern Va. Med. Sch., Norfolk, Va. 23501

The outbreak of influenza at Fort Dix in February, 1976, and isolation of A/swine/NJ/76 led to concern that this virus might spread in hogs and then to humans. Since Eastern Virginia is a major hog raising and processing center, a study was undertaken to determine the extent of virus activity as indicated by hemagglutination inhibition titers in selected hog population samples.

Through the courtesy of the Smithfield Packing Company, sera were obtained from a total of 1,484 hogs coming to slaughter at intervals over a seven-month period. Separate bleedings were made in September and December, 1976, and in March, 1977. These samples have been broken down further to the state of origin for many of the hogs. All samples have been tested against the swine virus (A/swine/NJ/76) and the current human A strain (A/victoria). All reagents have been provided by the Division of Virology, Center for Disease Control, Atlanta, Ga.

Comparative frequencies of positive titers will be discussed with reference to the two virus strains, the geographical distribution and the time at which samples were obtained.

FUNCTIONAL ACTIVITY OF THE RETICULOENDOTHELIAL SYSTEM (RES) IN MICE EXPOSED TO THE HALOMETHANES, DRINKING WATER CONTAMINANTS. V.M. Sanders\*, B.A. Barrett\*, J.F. Borzelleca and A.E. Munson, Dept. of Pharm., Med. Col. of VA., Richmond, VA. 23298

Adult and weanling ICR Swiss mice were gavaged with a single or 14 daily doses of trichloromethane ( $\text{CHCl}_3$ ), bromodichloromethane ( $\text{BrCHCl}_2$ ), dibromochloromethane ( $\text{Br}_2\text{CHCl}$ ), or tribromomethane ( $\text{Br}_3\text{CH}$ ). The lowest dose was 100 x the maximum ambient environmental water levels, the highest the maximum  $\text{LD}_{50}$  in mice. RES function was determined by blood clearance and organ distribution of  $^{125}\text{I}$ -labelled *Listeria monocytogenes*. Male mice appear to be more sensitive than females. In adult males,  $\text{CHCl}_3$  caused an inhibition of the global phagocytic index (PI) at the lowest dose levels and a stimulation at the highest, whereas male neonates expressed a dose dependent inhibition. Hematological changes were evident in both sexes and may be indicative of other changes occurring in the system, i.e. bone marrow depression.  $\text{BrCHCl}_2$  produced a depression of the PI in males dosed acutely (AC) and subchronically (SC) at the lower doses. Only AC exposure caused an inhibition in adult females.  $\text{Br}_2\text{CHCl}$  caused a dose dependent stimulation of the PI in mice dosed SC.  $\text{Br}_3\text{CH}$  produced a change in adult males dosed SC where there was an inhibition of the PI at the lowest dose. All the halomethanes caused hepatomegaly. Studies of the functional activity of the RES may be a valuable tool in evaluating potential environmental hazards to the mature, and the developing immune system. Supported by EPA Grant R804701010.

THE EFFECTS OF  $\Delta^9$ -TETRAHYDROCANNABINOL ( $\Delta^9$ -THC),  $\Delta^8$ -THC, AND 1-METHOXY  $\Delta^8$ -THC ON HUMORAL AND CELL-MEDIATED IMMUNITY. S.H. Smith\*, and A.E. Munson, Dept. of Pharm., Med. Col. of VA. Richmond, VA. 23298

Delta-9-THC, a psychoactive constituent of marihuana, has been shown in previous studies to suppress humoral and cell-mediated immunity. The objective of this study was to determine if structural modification of  $\Delta^9$ -THC would result in a more potent immunosuppressant agent devoid of central nervous system (CNS) activity. Humoral immunity was measured in BFD<sub>1</sub> male mice immunized with  $4 \times 10^8$  sheep erythrocytes (sRBC) i.p. on day 0, and  $\Delta^9$ -THC administered at 75 mg/kg i.p. on day 2. The  $\text{ED}_{50}$  for reduction of spleen hemolytic plaque forming cells (PFC)/ $10^6$  spleen cells by  $\Delta^9$ -THC on peak day of response was 70 mg/kg. Compared to  $\Delta^9$ -THC,  $\Delta^8$ -THC and 1-methoxy  $\Delta^8$ -THC were more potent in suppressing the primary antibody response with  $\text{ED}_{50}$ 's of 14 and 13 mg/kg respectively. Cell-mediated immunity was measured by a delayed type hypersensitivity (DTH) response to sRBC. Mice were sensitized with  $10^5$  sRBC i.v., and the cannabinoids were administered on days 0-3 at 100 mg/kg s.c. On day 4 the left hind footpad was challenged with  $10^8$  sRBC, and footpad swelling was measured 24 hr later. Delta-9-THC,  $\Delta^8$ -THC, and 1-methoxy  $\Delta^8$ -THC inhibited footpad swelling by 68, 55, and 57% respectively. Since 1-methoxy  $\Delta^8$ -THC has minimal CNS activity, this study shows that the cannabinoids can cause immunosuppression which is not related to CNS activity. Supported by USPHS grants T32DA07027 and DA01312.

INTRACELLULAR CALCIFICATION: CYTOPLASMIC LITHOSOMES IN A CILIATE PROTOZOAN. John J. Ruffolo, Jr. Dept. of Biophysics, Med. Col. of Va., Richmond, Va. 23298

*Euplotes* is a protozoan in the Phylum Ciliophora and Order Hypotrichida. It is a unicellular eukaryote, and by virtue of the fact that it contains mineral concretions in its cytoplasm, this cell can be used as a model system for the study of the formation, composition, and regulation of intracellular mineral deposits.

All the inorganic calcium salts found in higher plants and animals can also be found in unicellular organisms, including calcium carbonate and calcium phosphate. The function of these intracellular microcalculi is not understood.

In *Euplotes eurystomus* I have studied the fine structure of cytoplasmic mineral concretions (lithosomes), and observed several stages of formation (and regression?) of these structures. The lithosomes remain small (about 1  $\mu\text{m}$  in diameter), and are formed and retained within membrane-bound vacuoles. It is likely that the lithosomes are calcium deposits either with carbonate or phosphate, but their composition has not yet been analyzed. The fine structure of various stages of lithosome formation suggests that organic material participates in the process of mineralization.

BASIS OF THE ENHANCED SUSCEPTIBILITY OF MICE TO COMBINATIONS OF  $\Delta^9$ -TETRAHYDROCANNABINOL AND BACTERIAL LIPOPOLYSACCHARIDE. M. Smith\* and S.G. Bradley, Virginia Commonwealth University, Richmond, Va. 23298

A combination of  $\Delta^9$ -tetrahydrocannabinol (150 mg  $\Delta^9$ -THC/kg) and bacterial lipopolysaccharide (1.5 mg LPS/kg) given to mice simultaneously by the intraperitoneal route resulted in enhanced mortality. Concanavalin A had little effect on the susceptibility of mice to  $\Delta^9$ -THC. ICR mice rendered resistant to endotoxin by prior treatment with *Escherichia coli* 0127:B8 (Westphal) LPS remained susceptible to  $\Delta^9$ -THC whereas mice previously treated with  $\Delta^9$ -THC became resistant to  $\Delta^9$ -THC and LPS singly and in combination. Mice previously treated with phenobarbital remained susceptible to  $\Delta^9$ -THC and LPS singly and in combination. The C3H/HeJ mouse, which is genetically hyporesponsive to LPS, was also resistant to the lethal action of  $\Delta^9$ -THC.  $\Delta^9$ -THC caused hypothermy and reduced activity of C3H/HeJ mice. The activity of the lysosomal enzyme  $\beta$ -glucuronidase was decreased in the 400,000 g-min residue from liver, increased in the 400,000 g-min supernatant fraction from kidneys and unaltered in fractions from spleens of mice given 300 mg  $\Delta^9$ -THC/kg 18 h before removing the organs. LPS at 10  $\mu\text{g}/\text{ml}$  (cf.  $\text{LD}_{50}$ =12  $\mu\text{g}/\text{g}$  mouse wt.) did not overtly injure spleen cells in culture but elicited enhanced lysosomal enzyme activities.  $\Delta^9$ -THC at 50  $\mu\text{g}/\text{ml}$  (cf.  $\text{LD}_{50}$ =300  $\mu\text{g}/\text{g}$  mouse wt.) overtly injured spleen cells *in vitro* but did not drastically alter lysosomal enzyme levels.

RELATIONSHIPS BETWEEN BACTERIAL POPULATIONS AND ABIOTIC PARAMETERS IN AN ACID MINE DRAINAGE SYSTEM. M. Stallard\*, E. Blood\*, and J. Gates. Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284

Correlations were found between numbers of cells of *Thiobacillus* species and various physical parameters in water samples collected at the Sulfur Mine Site on Contrary Creek in Louisa Co., Va. Significant positive correlations existed between numbers of thiobacilli and concentrations of copper ( $R=0.99$ ) and iron ( $R=0.75$ ), turbidity ( $R=0.66$ ), and temperature ( $R=0.61$ ). Significant negative correlations existed with hardness ( $R=0.69$ ) and pH ( $R=0.61$ ). No significant correlations were found between numbers of thiobacilli and numbers of chemoorganotrophic bacteria, dissolved oxygen, and concentrations of manganese, cadmium, lead, mercury, or zinc. No significant correlations existed between numbers of chemoorganotrophic bacteria and any physical parameter studied.

Regression analyses indicated that copper was the best single parameter in predicting change in numbers of thiobacilli with 99% of the changes in numbers of these bacteria being explainable by change in concentration of this metal ( $R^2=0.99$ ). Other significant regressions were found between numbers of thiobacilli and iron concentration ( $R^2=0.56$ ), turbidity ( $R^2=0.48$ ), hardness ( $R^2=0.48$ ), temperature ( $R^2=0.37$ ), and pH ( $R^2=0.37$ ). These observations are consistent with the roles believed to be played by these bacteria in the formation of acid mine drainage.



INFLUENCE OF ENVIRONMENTAL STRESS ON MUTAGENICITY IN MICE.  
Tang, T., A.N. Tucker and M.A. Friedman. Dept. Microbiol. and Pharmacol., Med. Col. of Va., Richmond, VA 23298

Liver microsomal monooxygenase systems which metabolize foreign substances including chemical carcinogens are affected by environmental stress. We have evaluated the effects of endotoxin intoxication, hyperthermic, cold and crowding stress on enzyme mediated mutagenicity and liver enzyme activities in male BALB/c mice. Enzyme mediated mutagenicity of aflatoxin B<sub>1</sub> (AFB<sub>1</sub>), 3-methylcholanthrene (3MC), benzidine (BZD) and 2-acetylaminofluorene (AAF) was determined in *S. typhimurium* TA 100. Liver enzymes from cold-stressed mice showed the highest mutagenicity for AFB<sub>1</sub>, 3MC and BZD. Crowding stress induced a high level mutagenicity only for AAF. Endotoxin and hyperthermic stress increased the mutagenicity of only selected compounds. The concentration of cytochrome P-450 was reduced by 70, 62, 76 and 0% in mice stressed with endotoxin, hyperthermic, cold and crowding, respectively. Aniline hydroxylase (AH) activity was unaffected by endotoxin and crowding stress, decreased by hyperthermic stress and increased by cold stress. Cold stress did not affect aminopyrine demethylase (APD) activity, but endotoxin reduced APD activity to 75% of control. Crowding and thermal stress increased APD activity by 50 and 100%, respectively. These data indicate that environmental stresses significantly changed hepatic monooxygenase activities measured chemically or as the ability to mediate the mutagenicity of environmental carcinogens. (NIH grant ES00701 and ACS grant IN-105-B).

EXTRACHROMOSOMAL ELEMENTS IN STRAINS OF *STREPTOCOCCUS MUTANS* ISOLATED FROM WILD RATS AND FROM INFECTED HUMAN BLOOD.  
S. S. Virgili\* and F. L. Macrina. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, Va. 23298.

Plasmid pVA380, discovered in a strain of *Streptococcus mutans* isolated from a wild rat's mouth, was determined by neutral sucrose gradient analysis to have a molecular size of 2.2 Mdal. CsCl-ethidium bromide gradient centrifugation revealed that 65 copies of the plasmid exist per chromosomal genome equivalent (CGE). Plasmid pVA403, isolated from infected human blood, was in like manner determined to have a molecular size of 3.5 Mdal and a copy number of 36 per CGE. Biochemical analysis showed that strain V380 belonged to a newly formed subspecies (*ferus*), while V403 was a member of subspecies *mutans*. No phenotypic trait could be directly ascribed to the plasmids. However, strain V403 contained a bacteriocin-like activity which was active against many other streptococci and a *Staphylococcus*, but not against itself or against several gram negative organisms. A plasmid identical to pVA380 was found in a second independently isolated strain of rat origin. pVA403 is similar in size to plasmids contained in 3 independently isolated strains of human dental plaque origin. Comparative studies of these plasmids is currently in progress (supported by NIH-NIDR grant DE04224).

PHYSIOLOGIC DIFFERENCES OF PATHOGENIC AND NONPATHOGENIC NAEGLERIA. R. R. Weik\* and D. T. John. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, VA 23298.

*Naegleria fowleri* causes a rare but fatal disease in man while *N. gruberi* is a ubiquitous free-living ameba. *N. fowleri* (LEE) and *N. gruberi* (EGB) were cultured axenically with agitation in Nelson's medium and in Band and Balamuth's hemin medium, respectively. At intervals samples were taken for cell counts, pH determinations, cell size and biochemical analyses. The pH of the growth medium increased during logarithmic growth phase and stationary phase of *N. fowleri* but did not change during log growth of *N. gruberi* until near stationary phase. The pH optimum for growth initiation in agitated cultures was 5.5 for *N. fowleri* and 6.5 for *N. gruberi*. Oxygen tension of the growth medium decreased from 100% saturation to 18% and 78% during log growth of *N. gruberi* and *N. fowleri*, respectively, and then increased during stationary growth to near saturation. Cell size was 1000  $\mu\text{m}^3$  for *N. gruberi* and 400  $\mu\text{m}^3$  for *N. fowleri* during log growth. Glucose and total carbohydrate assays of the culture medium showed little utilization of glucose or carbohydrate; however, glucose was metabolized during stationary phase of *N. gruberi*. All of 6 strains of *N. gruberi* agglutinated in the presence of 1  $\mu\text{g}/\text{ml}$  of Concanavalin A while none of 10 strains of *N. fowleri* agglutinated. These results indicate that significant physiologic differences occur with virulence differences in *Naegleria*.

# Section of Psychology

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

THE EFFECTS OF UNCONTROLLABLE OUTCOMES: LEARNED HELPLESSNESS VERSUS REACTANCE. Mark Albert\*, Carol Pilgrim\*, Jacqueline Read\*, and E. Scott Geller. Department of Psychology, VPI&SU, Blacksburg, VA 24061.

In an attempt to further investigate the relationship between learned helplessness and perceived locus of control reported to the Academy last year by Albert, Miller, and Geller, subjects participated in two separate tasks. In the first task subjects viewed patterns of lights flashed on a 4x6 bulb grid and attempted to predict upcoming stimuli. Regardless of their predictions, logic equipment determined that subjects would be correct on either 80% of 20% of the trials. In the second task, subjects attempted to memorize a list of words presented serially by a slide projector.

Subjects in the 80% correct condition rated their performance as significantly more successful than did subjects in the 20% condition. Further, subjects previously determined to hold an external perception of control who had been unsuccessful on the first task performed significantly worse on the second task than did subjects holding an external perception of control who had been successful on the first task. This relationship did not hold for Internal subjects, who actually tended to perform better following failure rather than success on the first task. However, this difference was not significant according to a test for simple effects.

These results are interpreted as supporting Wortman and Brehm's hypothesis concerning the interaction between learned helplessness and reactance

PSYCHOLOGICAL ANDROGYN: A CRITICAL VARIABLE IN UNDERSTANDING SEX DIFFERENCES IN SOCIAL CONFORMITY RESEARCH. Mark N. Augustine, William H. Woodhouse, Nancy E. Miller and Kathleen A. Brehony. Dept. of Psychology, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Recent concerns regarding sex-role stereotyping include suggestions that observations of differential behavior as a function of physical sexuality may be misleading. It is possible that the extent to which an individual adheres to a particular sex-role stereotype may be more predictive of his/her behavior in a given situation than is his/her physical sexuality. The concept of androgyny offers an alternative to viewing masculinity and femininity as bipolar extremes of a single continuum. From the Greek "Andro" for male and "Gyn" for female androgyny defines a condition under which individuals do not rigidly adhere to role characteristics of the sexes (Heilbrun, 1973). The decisions and attitudes of sex-stereotyped and androgynous individuals (as defined by the Bem Sex Role Inventory) were compared in a social conformity paradigm. On each of 160 trials subjects predicted one of two possible stimuli after hearing predictions of two other "subjects". No effects of physical sex were observed. On trials when the confederates predicted the same stimulus, stereotypic females conformed significantly more often than androgynous females, androgynous males and stereotypic males (N=20 for each group). In a post-experimental questionnaire, stereotypic females indicated that they were most influenced by the other "subjects".

PRELIMINARY INVESTIGATION OF THE SOCIAL/PSYCHOLOGICAL ASPECTS OF STRIPTEASING. Helen J. Barker. Department of Psychology, Randolph-Macon Woman's College, Lynchburg, Va. 24503

The major purpose of this investigation was to determine some of the salient social/psychological variables involved in the occupation of stripteasing. Structured interviews were conducted with twenty-six professional striptasers; these were conducted on location in the northeastern, southeastern and midwestern United States. Preliminary analysis indicates that besides monetary reasons other social and psychological factors are important in determining the selection of this occupation. Comparisons of professional striptasers to other occupational groups on these variables were made.

A METHOD FOR THE REDUCTION OF INTERGROUP HOSTILITY IN THE CLASSROOM. G. L. Brittingham\* and V. A. Andreoli\*. Dept. of Psychology, Madison Col., Harrisonburg, VA 22801

The study investigated the effectiveness of the superordinate goal technique in reducing intergroup hostility in the classroom. It was predicted that participation in a superordinate goal would increase attraction between previously competitive groups. Students from grades 2, 3, 4, and 5 participated in the three week project. During the first week each 4 or 5 person group cooperated on several tasks. In the second week two groups competed against each other on a series of tasks. Finally, the previously competing groups cooperated together to achieve on two superordinate goals. Measures of attractiveness were taken one week before the project, after intragroup cooperation, after intergroup competition, after cooperation on the superordinate goal and four weeks after the superordinate goal week. The results indicated that the cooperation on the superordinate goals did significantly increase the attractiveness of the out group.



PROCESSING OF COLORS AND COLOR-NAMES IN THE LEFT AND RIGHT CEREBRAL HEMISPHERES. Michael J. Burns\*. Washington and Lee Univ., Lexington, Va. 24450

Nine subjects received tachistoscopic presentation of a cue stimulus comprised of four rectangles each of which contained either a different color or a different color name. After a 1-sec delay a test stimulus consisting of a second series of four rectangles was presented to either the right or the left visual field via the tachistoscope. Only one rectangle of the test stimulus contained a color or a color name. The task was to manually indicate whether the color or color name on the test stimulus corresponded with the position of the same color or color name on the cue. In two additional experiments, interpolated activity between cue and test was introduced either on every trial (Experiment 2) or on a random half of the trials (Experiment 3). Reaction times were found to be shorter for color tests than for color-word tests in all three studies. A right hemisphere advantage for color processing and a left hemisphere bias for color-name processing were found in some conditions.

ANXIETY AND DEFENSIVE STYLE AS A PREDICTOR OF RESPONSE TO SURGERY. J. Burnside, L. Scott and G.A. Clum. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The present study was aimed at articulating the relationships of anxiety and defensive style (copers vs. avoiders), as measured prior to surgery, to post-surgery outcome. Outcome was measured via a number of "hospital criteria" including length of hospital stay, number of complications and number of days to ambulation. Post-surgery anxiety was also assessed. The results were analyzed via multiple regression equations of the pre-surgery to outcome variables. These results were then discussed in terms of the interaction of anxiety and coping style as they relate to the individual's ability to deal with stress.

KIRLIAN EFFECTS IN NATURAL CHILDBIRTH. David B. Cammack\* and Wayne Richard\*, Dept. of Psychology, Tidewater Community College, Virginia Beach, Virginia 23456.

Since its introduction into the U.S. in 1970, Kirlian photography, the technique which records on film "energy fields" emanating from objects, has been suggested as a potential medical diagnostic tool and adjunct to psychological inventories. The research reported herewith is a pilot study of changes in the Kirlian field around the finger pad of a woman during natural childbirth.

In an attempt to make Kirlian photography acceptable to Western science, the researchers controlled for or monitored over 30 experimental variables, including finger pad surface moisture. According to a Nov. 1976 release by the International Kirlian Research Association their investigation employed "the best standardized techniques used to date."

Before labor began the researchers took over 100 control shots to establish the subject's normal state. Throughout labor and delivery the researchers made written records of the subject's reported changes in her psychological, emotional and physiological states, and recorded on sound tape all interpersonal interactions with the subject. Kirlian field changes around the subject's finger pad during natural childbirth were interpreted as suggestive of the combinative influences of alterations in the subject's psychological, emotional and physiological states; alterations traceable, in part to subject directed interpersonal interactions.

A BEHAVIORAL ANALYSIS OF SEAT BELT WEARING.

John C. Casali\*, Kim Cuddihy\*, Kim High\*, and E. Scott Geller. Dept. of Psychology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Seat belt wearing practices of student and staff members of VPI & SU were directly observed as they entered and exited campus parking lots. By questioning voluntary drivers, several variables which might affect seat belt wearing were studied.

Individual variables included driver's sex and marital status. Also investigated were the various types of reminder or warning devices present in all U.S. manufactured cars since the late 1960's as to their effectiveness in inducing seat belt usage. Additionally, the incidence of disconnecting or making the warning device inoperative was studied. Devices investigated were: limited light, 3-10 seconds duration; unlimited light, on until belt buckled; limited buzzer, 3-10 seconds duration; unlimited buzzer, on until belt buckled; and interlock, car won't start until belt buckled. Findings indicated that more females than males wore seat belts. Interlock, unlimited buzzer, and unlimited light showed the highest behavioral evidence of seat belt use in that order. Unlimited buzzer, followed by interlock was most frequently disconnected. The data indicated that the intrusiveness of the device affects seat belt wearing behavior.

THE ROLE OF THE PREFRONTAL CORTEX IN THE RETENTION OF SPATIAL MEMORY IN RATS. S.L. Craig, Jr. (Sponsor: L.E. Jarrard) Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

The intent of this study was to determine the effects of selective lesions of the prefrontal cortex on the retention of a complex spatial task. Preoperative training consisted of 15 days of testing on an 8-arm radial maze in which all 8 arms were baited. Following acquisition the 9 rats were divided into 3 groups of 3 subjects that were matched for performance. One group served as an unoperated control; aspiration lesions of either the orbital or anteromedial prefrontal cortex were performed on the other two groups. Postoperative testing indicated that the groups did not differ in performance. Further testing involving baiting only one of the eight arms for ten days revealed a significant impairment in anteromedially lesioned subjects. Overall results suggest that neither the anteromedial nor the orbital prefrontal cortex is involved in retention of the spatial task.

MENTAL PRACTICE, MEMORY SEARCH, AND REACTION TIME Mary DeCicco, Shari Hicks, Steve McConnell, and Mark Albert. Dept. of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

The effects of mental practice on reaction time were investigated using a Sternberg reaction time task of 250 trials. The 250 reaction time trials occurred after one of four "practice" conditions: Real Practice (RP) where subjects were given 100 practice trials whereby they pulled one of the two response triggers to identify whether the stimulus was a member of a critical set of stimuli, Imagine Positive (IP) where the subjects memorized the same critical set as used in testing and imagined pulling the triggers to identify positive and negative memory set stimuli, Imagine Negative (IN) where the subjects memorized a critical set not used in testing and imagined pulling the triggers to classify stimuli as positive or negative set-items, and No Practice (NP) where the subject was told only to watch the stimuli appear on the screen. The results only partially supported the hypothesis, that mental practice would facilitate reaction time. Specifically, reaction time went from shortest to longest in the following order: Group (RP), Group (NP), Group (IP), and Group (IN). The slope of the function relating reaction time to the number of items in the memory set demonstrated that subjects searched faster the memory set they had previously practiced mentally.

THE MODIFICATION OF PAPER RECYCLING BEHAVIOR IN A COLLEGE DORMITORY. Terry Garber,\* Lori Karpus,\* and James Couch. Dept. of Psychology, James Madison Univ., Harrisonburg, VA 22801

The effects of reinforcement on paper recycling was investigated in two female dorms. An ABA design was used. In both dorms a six-week raffle condition increased the return of recyclable paper over the baseline condition. The number of raffle tickets given to each student was dependent upon the number of pounds of paper returned. Weekly drawings were held in which three prizes were awarded in each dorm. Even though a significant increase in returned paper was found only 27% of the combined populations participated in the project. Removal of the raffle contingencies resulted in a return to baseline levels in both dorms. Lack of high participation levels and lack of response maintenance is discussed.

PCPA INDUCED HYPERACTIVITY IN HIPPOCAMPAL LESIONED RATS: DAY-NIGHT VARIATIONS. E. B. Gerhardt\* and B. Tray\*. (Sponsor: L. E. Jarrard), Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

The purpose of this experiment was to see if PCPA, a whole-brain serotonin depletor, has a similar effect on spontaneous locomotor activity of hippocampectomized and normal rats. Eating and drinking were also measured. Four rats received complete hippocampal lesions by aspiration and their behavior was compared to unoperated (N = 2) and neocortical lesioned controls (N = 2). Following a 2 week recovery period all subjects were injected with 300 mg/kg of PCPA. It was found that PCPA increased activity in both hippocampal and control rats during the day for 3 days. These results do not agree with previous reports that suggest the hippocampus is involved in the mediation of PCPA induced hyperactivity.

THE EFFECTS OF DIFFERENTIAL HIPPOCAMPAL LESIONS ON BEHAVIOR IN THE RAT. L.E. Jarrard. Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

The available neuroanatomical and neurophysiological evidence indicates that the hippocampus consists of at least two main subdivisions. Behavioral evidence relating to the question of functional differences within the structure has been lacking. In the research to be reported different hippocampal subdivisions and/or efferent projections were lesioned and the rats were tested on a series of tasks chosen to measure various aspects of motivation and response perseveration. The results indicate that the two main subdivisions, the CA1 and CA3 cell fields, are differentially involved in behavior. The results will be discussed as they relate to current theories of hippocampal function.

THE EFFECTS OF DEEP AND SHALLOW PROCESSING OF NONSENSE FIGURES ON RECALL. Mickey Knapp\* 301 E. Washington St. Lexington, Va.

The present experiment is designed to test Craik and Lockhart's (1972) "depth of processing" model of memory for the processing of nonsense figures. Sixteen subjects were instructed to process nonsense figures according to shallow verbal, deep verbal, shallow non-verbal, and deep non verbal tasks, and were subsequently asked to recognize the figures. The experiment was designed to further define and clarify Craik and Lockhart's notion that perceptual tasks that lead to deeper levels of processing are crucial in facilitating subjects' subsequent ability to recall. The results show that greater depths of processing do lead to an increase in rate of recognition of nonsense figures with respect to both verbal and non-verbal incidental learning tasks. The findings give support to and provide a broader experimental base for Craik and Lockhart's "depth of processing" model of memory.

STRESS AND LOCUS OF CONTROL AS FACTORS IN SUICIDE ATTEMPTING. R. Luscomb, A.C. Tracy, and G. A. Clum. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The present study was aimed at differentiating a group of suicide attempters (N=50) from a group of psychiatric controls (N=50). It was hypothesized that the parasuicide group would score higher on the external locus of control dimensions, have a higher level of stress and be classifiable as defensive externals compared to the control group. Correlations between each of these three predictors and the dichotomous criterion of parasuicide vs. control demonstrated support for the greater externality of the suicide group but only partial support for each of the other two hypotheses. The results were discussed in terms of the etiological factors of suicide attempting.

LIMITING CONDITIONS ON FACILITATING LITTER CONTROL. M. F. Mann\*, W. S. Brasted\*, M. Augustine, E. S. Geller, Dept. of Psych., Va. Polytechnic Inst., Blacksburg, Va. 24061

Much research has reliably demonstrated that behavioral prompts cause compliance. Typically, prompts have employed a general anti-litter request and a request or demand to use a specific trash can. Some of the past results suggested that specific requests were less effective than general requests in a movie theatre. This study is based on the supposition that freedom to litter was threatened by a specific request in a movie theatre; people may feel that they have a right to litter at the movies. They experience reactance, a motivational state which is directed towards reasserting a threatened or eliminated behavioral freedom.

This study used three prompts: General prompt, "Please do not litter;" Specific prompt, "Please dispose of in trash can in front of..." Demand prompt, "You must dispose of in trash can in front of..." For all handout locations it was demonstrated that the specific prompt was more effective in eliciting disposals in the specified trash can than the general prompt, but less effective than the demand prompt. Demand prompts caused reactance when people were either ordered to go across the mall and instead chose to use an attractive alternative trash can that looked like the state bird (standard trash cans were designed to be unobtrusive) or were faced with a concentration of anti-litter stimuli, the demand prompt and "bird can" simultaneously.



SPATIAL FACTORS AS DETERMINANTS OF SOCIAL CONFORMITY. Anne E. McGovern\*, Shari D. Hicks\*, David Barachie\*, and E.Scott Geller. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The effects of spatial distance and initial competence of a reference group on conformity were investigated. Each subject and two confederates sat on stools 18 in. (Close condition) or 70 in. (Far condition) apart, and for each of 160 trials, predicted which of two stimuli would appear on a screen. In the first block of 40 trials, the confederates were correct on 25%, 50%, or 75% of the trials. In the remaining blocks, the confederates were always correct on 50% of the trials. The confederates predicted the same stimulus on 50% of the trials. The analysis included a measure of the frequency with which the subjects agreed with the confederates on those trials in which the confederates agreed with each other. A significant Competence X Trial Block X Distance interaction was found ( $p < .05$ ). On the first trial block, subjects agreed more often in the Close than Far condition when the confederates were 75% correct. Subjects agreed more often in the Far than Close condition when the confederates were 25% correct. When the confederates were initially 50% correct, a significant Trial Block X Distance interaction indicated that subjects' agreement decreased over trial blocks in the Close condition, but increased over trial blocks in the Far condition.

Thus, subjects appeared to be more attentive to the confederates' competence level in the Close than Far condition.

THE EFFECT OF SEX ON NONVERBAL COMMUNICATION AND BETRAYAL OF FEELING. H. Thomas Mullis\*, Sam L. Hutchison, Jr.\*, Dept. of Psychology, Radford College, Radford, Va. 24142

The possible effects of sex on nonverbal communication and betrayal of feeling were examined by having eight groups of 18 male and female undergraduate subjects (observers) shown videotapes of other students (actors) making a statement concerning a controversial issue (abortion). The observers were asked to detect whether or not the actors were stating their true feelings. The following factors were varied: (1) sex of actor, (2) truth or falsity of actors' feelings, and (3) previously stated attitude (pro or con) of actors.

Analyses indicated that the observers as a group were significantly able to detect whether the actors were telling the truth. Female subjects were able to detect truthfulness on the part of a female actor when the actor was truthful and for abortion. In addition, sex differences were found in relationship to the observer's confidence in judgement.

TRAINING UNDERGRADUATES IN HELPING SKILLS AND PRIMARY PREVENTION ON THE UNIVERSITY CAMPUS. E.J. Nottingham, IV\*, R.E. Mattson\*, and L.D. Dewitt\*. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va., 24061

Investigations have revealed the increasing incidence of psychological disturbances among university students, however, little research has explored methods of reducing the incidence of dysfunctioning among these students. This study was designed to reduce the occurrence of psychological discomfort as well as increase the positive perceptions of the residential environment. The intervention consisted of training a group of undergraduate volunteers in basic helping skills. Several pre-training measures were obtained from the male and female training floors (TF) and non-training floors (NTF). Following the seven week training period the residents were administered the same measures. Results showed that the TF residents became significantly more adjusted as measured by the Kleinmuntz Maladjustment Scale, and also showed significant changes in terms of the amount of interaction and feelings of friendship as measured by the University Residence Environment Scale. NTF residents showed decreases on both measures. Therefore, the authors see this intervention as a promising one, but regard the present investigation as a pilot project due to the small number of trainees and to the number of students who completed the pre and post measures.

INDIVIDUAL DIFFERENCES AND ASSIGNMENT TO THERAPY. C. Pickett\*, and G.A. Clum\*. Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061

The present review examined studies investigating the interaction of individual differences and various treatment procedures. Individual differences reviewed were Rotter's internal-external locus of control construct, introversion-extraversion, authoritarianism, expectations of a particular social class, and psychological-mindedness. These personality variables were examined as they interact with various psychotherapy procedures and specific behavior modification techniques used in smoking modification and weight control. The results of the studies were examined with regard to both patient preference for therapy and outcome of therapy. Data from these studies were critiqued as to their methodological inadequacies and their contribution to the patient-therapy matching problem.

THE RELATIONSHIP BETWEEN COLLEGE FOOTBALL PLAYER ATTITUDES AND TURNOVER: A STUDY OF THE PREDICTIVE VALIDITY OF THE ATHLETIC MOTIVATION INVENTORY (AMI). D. M. Saverline\*, and J. A. Sgro. Dept. of Psychology, Va. Polytechnic Inst. and St. Univ., Blacksburg, Va. 24061

The Athletic Motivation Inventory (containing 13 attitude and behavior scales) was administered to 91 college football players. In the ensuing three years the number and identity of players who quit for reasons other than injury and graduation were noted. Stepwise regression procedures were computed for the prediction of quit/no-quit criterion. Significant predictors were not found for the entire sample. However, when status (substitute or regular) was used as a moderator, significant results yielded a set of predictors for substitutes which was different from the set of predictors for regulars. The results are discussed in terms of situational variables that may account for the differences.

THE PREDICTION OF POST-SURGICAL PAIN FROM PERSONALITY VARIABLES. L.E. Scott\*, J.C. Burnside\*, and G.A. Clum\*. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

This study examined the effects of anxiety, information, and fear on the magnitude of perceived pain in 50 surgical patients. The State-Trait Anxiety Inventory (STAI), the McGill Pain Questionnaire (MPQ), and the Fear of Surgery Schedule (FSS) were given the day before the operation and again five days after surgery. A rating of each patient's knowledge of possible complications, preparatory procedures, and the kinds of pain he might experience was obtained from a taped interview.

Data was evaluated by multiple regression analyses to formulate prediction equations for the report of post-surgical pain. It was expected that trait anxiety would be the most important predictor and that information would be the next most important predictor. It was also hypothesized that high levels of information would coincide with higher levels of perceived pain, but with lower ratings of fear of surgical operations. And finally, it was proposed that, when levels of information are held constant, there is a positive correlation between fear of surgery and reported pain.

MODALITY EFFECTS IN SHORT- AND LONG-TERM MEMORY SCANNING. B. Tomlinson\*, A. Penello\*, and E. D. Smith. Dept. of Psychology, Longwood Col., Farmville, Va. 23901

Speed of memory scanning for a set of five positive items was measured for short-term memory (presentation of the positive set followed immediately by the memory scanning test) and long-term memory (presentation and then the test following a 2 minute delay). The positive set was presented to subjects either visually or auditorily. In the memory scanning test the positive and negative items were always presented visually. It was hypothesized that the visual condition would respond faster than the auditory condition since the scanning test also involved visual presentation and that the immediate condition would respond faster than the delay condition, since the positive items might be more accessible. The results showed that the immediate condition performed significantly faster than delay condition, but no significant differences between modality of presentation.

COGNITIVE FACTORS DIFFERENTIATING PARASUICIDES FROM PSYCHIATRIC CONTROLS. A.C. Tracy\*, R. Luscomb\*, and G.A. Clum. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24060

The study examined three cognitive factors namely, cognitive rigidity, cognitive impulsivity, and field dependence, in order to determine what differentiates suicide attempters from psychiatric controls. The cognitive factors were assessed by four different instruments which were administered to both suicide attempters and non-suicidal psychiatric patients. Results indicated suicide attempters were significantly more cognitively rigid and cognitively impulsive than non-attempters. Field dependence did not differentiate between the groups. The results are discussed in terms of an assessment model utilizing a cognitive approach to the problem of predicting future suicide attempts.

PERSONALITY CHARACTERISTICS OF COLLEGE STUDENT LEADERS AS MEASURED BY THE EPPS. M. B. Williams\*, and E. D. Smith. Dept. of Psychology, Longwood Col., Farmville, Va. 23901

This study used five scales of the Edwards Personal Preference Schedule (EPPS) to determine the personality characteristics of student leaders. The Achievement, Affiliation, Dominance, Endurance, and Aggression scales were used. The subjects were college females who were divided into four categories consisting of student government officers, sorority presidents, athletic team captains and co-captains, and a randomly selected control group. Sorority presidents were found to be significantly more dominant, while the control group was significantly less dominant, than the other two groups.

STATE ANXIETY AS A FUNCTION OF INTERPERSONAL DISTANCE.

William H. Woodhouse, Jr., Nancy E. Miller, Marie Blanchet, and Mark Albert. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24060

This investigation examined variables (room size and interactive distance) with regard to the state anxiety and sex of the subject. This was accomplished by systematic behavioral observations and the administration of an environmental/state anxiety questionnaire before and after the experiment.

Eighty mixed sex dyads filled out an assessment questionnaire, were given instructions, then sat on stools in an empty room for fifteen minutes while behavioral data was recorded from behind a one-way mirror at ten second intervals. Both groups were informed that they would receive feedback on their performance: one via electric shock and the other via flashing lights.

Behavioral and anxiety questionnaire data indicated similar results. The results indicated no change in state anxiety in the flashing light condition. However, in the shock condition significant changes in state anxiety were noted in the close vs. for interaction dimension, but no other condition produced significant change in stress related feelings or behavior indicating an increased level of state anxiety.



# Section of Space Science and Technology

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

DEVELOPMENT OF LED DISPLAY FOR SOLO INSTRUMENT NAVIGATION. R. K. Crouch,\* B. D. Meredith,\* W. L. Kelly, IV,\* and L. J. Lina.\* NASA-Langley Research Center, Hampton, VA 23665

The workload for solo instrument flight, especially in rough air, can be almost beyond the capability of many relatively inexperienced pilots. In an IFR situation when time for each operational step is limited, it becomes very hard to follow or keep the proper location on a check list or navigational chart. At NASA, Langley, a program is being conducted to determine the feasibility of using LED's to display sequential instructions for machine or vehicle operations.

The LED prototype includes a paper tape reader, control circuitry, read/write memory, data latches and 21 LED alpha numeric characters. The series of instructions, stored on paper tape, are transferred to the memory when a read pulse from the control circuitry is activated by a push button switch. A write enable pulse, produced by the control circuitry, causes the information to be strobed onto the LED's.

Modifications and improvements that could be made in the design for a commercial device would include the use of microprocessors to greatly reduce the size and cost of the electronics. Such a device could be mounted directly on the instrument panel of a small general aviation aircraft.

The display is being tested in a NASA simulator to evaluate pilot acceptance of such a device.

DEVELOPING SAMPLING STRATEGIES FOR REMOTE SENSING SATELLITE MISSIONS. J. W. Drewry, NASA Langley, Hampton, Va. 23665

Earth orbiting satellites utilizing remote sensing techniques can provide various types of data coverage dependent on orbit and sensor design. Current and future missions utilize a variety of remote sensing instruments to detect surface or atmospheric features important to research in the areas of Earth resources, environmental quality, meteorology, atmospheric sciences, etc. The space and time scale of the data resulting from a combination of sensor capability and orbit characteristics determines the ability to recover the desired features. An appropriate sampling strategy will thus match sensor and orbit characteristics to provide data coverage to identify the features of interest.

The methodology for developing a sampling strategy will be described for the study of atmospheric constituents such as stratospheric ozone. The dependence of the results on both orbit/sensor selection and the assumed atmospheric model will be illustrated. A technique for defining high resolution global models to test both real and hypothetical sampling schemes will be described.

A NUMERICAL APPROACH TO SCRAMJET COMBUSTOR RESEARCH. J. P. Drummond\*, Hypersonic Propulsion Branch, High Speed Aero. Div., NASA Langley Research Center, Hampton, VA 23665.

Hydrogen fueled supersonic combustion ramjets (SCRAMJETS) offer the most promising propulsion option for various types of hypersonic aircraft. A program is currently underway at NASA Langley Research Center to develop such propulsion systems. The combustor flow fields found in these SCRAMJET engine concepts are extremely complex, but the fact that the flow field is single-phase and involves relatively well known chemical reactions permits optimism for detailed combustor analysis.

Combustor research at Langley is carried out both experimentally and analytically. The two approaches complement each other; the experiment provides data that supports development of the numerical model, and the numerical results give guidance when designing the experiment. The numerical effort has resulted in the development and application of several three-dimensional parabolic computer programs. One of these programs uses a finite element algorithm to solve the equations describing the flow field in a SCRAMJET combustor. Finite element techniques are attractive for such studies in that they adapt well to the complicated internal geometries found in the combustor. Results from the finite element program have compared favorably with several experimental cases and indicate that the numerical approach will provide a valuable tool in SCRAMJET research and development.

EFFECT OF INJECTION CONDITIONS AND INJECTOR SIZE ON THE INDUCED SHOCK WAVES IN SUPERSONIC NOZZLES. A. I. El-Sharkawy Dept. of Engr. Sci. & Mech., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061, and M.E. El-Sarha, Univ. of Technology, Baghdad, Iraq.

This paper presents the results of an experimental program to study the characteristics of shock waves induced by secondary injection into supersonic nozzles.

Air is injected into the divergent part of supersonic two-dimensional nozzles. The characteristics of the induced shock wave are examined by photographic recording of the flow using the schlieren technique. The shock wave angle is measured at different injection locations (Mach numbers), injector sizes, injection angles, and injection and mainstream stagnation pressures. The results show that the shock wave angle increases as the ratio between secondary total pressure and the static mainstream pressure increases, and as the injection angle is changed from downstream to upstream direction until a certain injection angle is reached after which the shock angle decreases. This limiting angle depends mainly on the injection pressure.

## AERODYNAMIC INTERFERENCE FORCES BETWEEN BLUFF BODIES.

C. J. Fahrner\* and Dr. D. P. Telionis, Engineering Science & Mech. Dept., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Experimental investigations have been conducted in the VPI & SU towing basin to assess the feasibility of testing fully submerged configurations, simulating aerodynamic phenomena, and in particular, measuring aerodynamic interference force between blunt bodies. Special instrumented struts were constructed and calibrated for the measurement of drag and side forces. A series of tests were conducted with spherical models in order to verify the reliability of the method by comparison with earlier classical results. The effects of flat walls and surface wave formation were studied and it was discovered that their influence on aerodynamic forces is reduced to less than 10% if the body is removed from the wall or the surface by a distance larger than half its typical width. Experiments were also conducted with crude models that approximate the shapes of a passenger car and a truck. In particular, the passing process under the presence of a strong wind was simulated by towing the models at an angle of  $24^\circ$  with respect to motion of the carriage. The results appear to be essentially in agreement with the data received with much larger models tested in air, by other investigators.

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## A LASER VELOCIMETER TECHNIQUE FOR MEASURING WAKE-VORTEX VELOCITY DISTRIBUTION. L. R. Gartrell\*, D. B. Rhodes\*, and C. E. Russ\*, NASA-Langley Research Center, Hampton, Virginia 23665

During the past several years, laser velocimeters have become a widely accepted technique for measuring the velocities of fluids. This technique is non-intrusive and operates on the principle of Mie scattering and Doppler effect. In a recent application of this technique a laser velocimeter system has been developed for measuring wake-vortex velocity flow field characteristics in the Langley Vortex Research Facility. This system incorporates a unique optical incremental scanning system (up to 30 Hertz), electro-optical acoustic Bragg cell for providing two simultaneous velocity components (tangential and axial) and removing direction ambiguity, digital frequency counters for signal processing and an online minicomputer system for data acquisition and processing. The system velocity resolution is better than 0.1 m/sec and typical standard deviation of the mean velocity values was  $\pm 0.3$  m/sec. This system has been used to measure wake vortices of model aircrafts. Some of the results of these tests will be presented.

## NITROGEN CONDENSATION STUDIES IN TRANSONIC CRYOGENIC WIND TUNNELS. R. M. Hall, NASA, Hampton, Va., 23665; D. G.

Pelaccio\*, Geo. Wash. Grad. Stu., Washington, DC, 20052; and S. A. Kramer\*, Univ. of Va., Grad. Stu., Charlottesville, Va., 22901

In order to realize the maximum benefit of cryogenic wind tunnel operation, the lowest possible operating temperature at which the data is free of real-gas effects must be determined for various test conditions. This minimum usable operating temperature is determined by the onset of condensation effects and is influenced by the tunnel total pressure, the local Mach number distribution over the model, and the model size. Determining the minimum operation temperature as a function of the above influences is the subject of a research program at the NASA Langley Research Center. Experiments using an NACA 0012-64 airfoil and total pressure probes in the Langley 0.3-meter transonic cryogenic tunnel suggest that the onset of condensation effects occurs at tunnel temperatures lower than might be expected. No effects are detected when the tunnel temperature is just low enough to allow saturation in the region of maximum local Mach number over the airfoil. In fact, no effects are detected until tunnel temperatures are below those corresponding to saturation in the test section. The research effort is now expanding to include other types of airfoils and to investigate length effects. In addition, an effort is underway to compare the data to existing theories. If transonic cryogenic wind tunnels can operate below saturation temperatures - as suggested by the results thus far - then significant savings in operating costs can be realized.

## EFFICIENT ACQUISITION OF DATA FROM SPACE. Lloyd S. Keafer, Jr.\* NASA-Langley Research Center, Space Systems Division, Mail Stop 364, Hampton, VA 23665.

More efficient sensing systems coupled with real-time management and low-cost distribution to "Users" of Earth observation data will enhance NASA's global service theme. This paper portrays a dual thrust in the development of space sensing systems which promises to meet the demands of the 1980's for information-intensive data acquired from space. Examples are given of IR laser and microwave radiometric technology being applied to both dedicated and multi-purpose sensors. A long-range moderate-cost program is outlined which emphasizes solving space sensor system engineering as well as sensor physics problems.

## JET DECAY RATE EFFECTS ON JET INDUCED LOADS ON A FLAT PLATE. J.M. Kuhlman, Assistant Professor, and R.W. Warcup\*, Research Assistant, Mechanical Engineering and Mechanics Department, Old Dominion University, Norfolk, VA.

Experimental modelling of the interaction between a jet and an aircraft wing or fuselage in VTOL aircraft was undertaken using a cold jet exiting perpendicular to a flat plate in a uniform crossflow. Effects of jet decay rate and jet-to-crossflow velocity ratio,  $R$ , on the induced load distribution were investigated. Jet decay rate was increased by using cylindrical centerbodies submerged in the jet nozzle, which caused non-uniform initial jet velocity profiles.

Quicker jet decay rate, corresponding to the presence of a centerbody, resulted in as much as a 50% reduction in the induced pressure loads on the plate. This has implications in interpretation of results from earlier VTOL model studies of jet induced loads, where the jets have most often had relatively slow decay rates due to uniform initial velocity profiles.

## PASSIVE SPACECRAFT ATTITUDE CONTROL USING MAGNETICALLY SUSPENDED MOMENTUM DEVICES. G.L. Sisson\*. NASA Langley Res. Center, Hampton, VA 23665.

This paper considers the use of magnetic bearings for dual-spin spacecraft systems. These magnetic bearings can be built with large radii, low drag torque, and are wear-free and vacuum-compatible with no need for lubrication. They also have the potential to produce system damping and act as effective nutation dampers.

The system model consists of two axisymmetric bodies, both of which can rotate and can have mass center offsets from the bearing center, coupled together with a six degree-of-freedom bearing. Linearized equations of motion are presented. Analytical stability criteria and numerical performance and associated suspension parameter data are presented for a simplified version of the system.

The main conclusion is that to fully realize the potential to stabilize spacecraft and produce system damping, active (force produced by electronically controlled magnetic fields) suspension including cross axis position feedback (force at one axis proportional to displacement at a perpendicular axis) should be used in the transverse rotational and translational directions. The use of active suspension allows the generation of relatively large damping forces and for the use of the cross axis feedback. The use of the cross axis position feedback is equivalent to changing the effective point of application of the damping and it can be adjusted to insure stability and to produce optimum system performance.



AERODYNAMICS OF SOME REENTRY SHAPES INCLUDING A SPHERE AND AN OBLATE SPHEROID. M. Leroy Spearman\*, High-Speed Aerodynamics Division, NASA Langley Research Center, Hampton, VA 23365

This paper will summarize the aerodynamics of some reentry shapes for Mach numbers in the range from about 0.6 up to 10.5. The principle emphasis will be on a sphere and a slightly blunted, or oblate, spheroid. The oblate spheroid is similar to the shape used by the Soviets in the early Vostok and Voskhod reentry vehicles. The drag for these shapes will be compared over the Mach number range and the sensitivity of drag to Reynolds number will be demonstrated. The drag levels for various other shapes including that for a flat-faced cylinder will also be shown.

Of particular interest is the static stability characteristics of the oblate spheroid. The results indicate a Mach number region above about  $M = 8$  wherein positive static stability might be achieved in spite of the negative lift curve slope and this may have been an influencing factor on the Soviet choice for this shape.

EVALUATION OF UPWELLING INFRARED RADIANCE IN A NONHOMOGENEOUS NONEQUILIBRIUM ATMOSPHERE. S. V. Subramanian\*, and S. N. Tiwari. Dept. of Mech. Engr. and Mechanics, Old Dominion Univ., Norfolk, Va. 23508

The primary purpose of this study was to investigate the influence of vibrational nonequilibrium upon upwelling infrared radiance from the earth's atmosphere. Basic equations are presented for calculating the atmospheric transmittance, heating rates, and equilibrium and nonequilibrium upwelling radiances. By employing the Lorentz line-by-line model for spectral absorption, heating rates and upwelling radiances were calculated for equilibrium as well as nonequilibrium conditions in the spectral range of  $4.6 \mu\text{CO}$  and  $3.3 \mu\text{CH}_4$  bands. For the spectral range of CO fundamental band, the influence of different parameters on the upwelling radiance was also investigated. The results indicate that for CO the assumption of LTE is not justified at tropospheric pressures and temperatures. For  $\text{CH}_4$ , however, the assumption is justified up to 60 kilometers. This information is very useful in developing an accurate data reduction scheme for the measurement of CO and  $\text{CH}_4$  concentrations in the atmosphere.

This work was supported by NASA-Langley Research Center through Grant NSG-1282.

EFFECT OF UPSTREAM ABSORPTION ON FLOW FIELD AHEAD OF A JOVIAN ENTRY BODY<sup>†</sup>. K. Y. Szema\* and S. N. Tiwari. Dept. of Mech. Engr. and Mechanics, Old Dominion Univ., Norfolk, Va. 23508

The change in flow properties, ahead of the bow shock of a Jovian entry body, resulting from absorption of radiation from the shock layer, is investigated. Ultraviolet radiation is absorbed by the free stream gases, causing dissociation, ionization, and an increase in enthalpy of flow ahead of the shock wave. As a result of increased fluid enthalpy, the entire flow field in the precursor region is perturbed. The variation in flow properties is determined by employing the small perturbation technique of classical aerodynamics as well as the thin layer approximation for the preheating zone. By employing physically realistic models for radiative transfer, solutions are obtained for velocity, pressure, density, temperature, and enthalpy variations. The results indicate that the precursor flow effects, in general, are greater at higher altitudes. Just ahead of the shock, however, the effects are larger at lower altitudes. Pre-heating of the gas significantly increases the static pressure and temperature ahead of the shock for velocities exceeding 36 km/sec. The agreement between the small perturbation and thin layer approximation results are found to be excellent.

<sup>†</sup>Supported by NASA-Langley Research Center through Grant NAS1-11707-92.

DESIGN OF SELF-CHECKING MICROPROGRAM CONTROL. M. R. Varanasi. Dept. of Electrical Engineering, Old Dominion University, Norfolk, Virginia 23508

The ability to apply efficient self-checking schemes in computer systems is a function of the complexity of the subsystem. Error detection and correction in memory and arithmetic units has received wide attention of researchers because of the regularity and modularity of the circuitry involved. Since the use of microprogramming permits the normally complex and irregular structure of the control unit to be designed in an organized and simple manner, the use of error detecting and correcting circuitry can be extended to control design.

This paper presents the design of a self-checking microprogram control unit for digital systems. The paper addresses the nature of errors and methods for detecting/correcting the errors dynamically by self checking. Since the checking methods are also subject to the same error probability, strategy by which the checking circuits can check themselves is presented. Although emphasis is given to the application of the control unit for fault-tolerant computer systems, the methods can be extended for use in any digital system design to ensure the availability and reliability of the system.

ISOTHERMAL TEMPERATURE OF THE MARTIAN ATMOSPHERE FROM STELLAR OCCULTATION. H. A. Wallio\* and M. L. Mason\*, NASA Langley Research Center, Hampton, Va. 23665

The observations of the April 8, 1976, occultation of Epsilon-Geminorum by Mars were used to derive the Martian isothermal atmospheric temperature over the ingress and egress points. A brief description of the experimental apparatus and the occultation theory is presented. The derived temperatures of  $193^\circ\text{K}$  for ingress and  $175^\circ\text{K}$  for egress, and their altitude ranges are discussed and compared to the recent Viking measurements.

A SIMULATION STUDY OF HEIGHT RECTIFICATION, A TECHNIQUE FOR ANALYZING EARTH RADIATION DATA. William L. Weaver, Aerospace Technologist, NASA Langley Research Center, Hampton, Virginia 23665

Knowing the amounts of solar energy the Earth reflects, absorbs, and re-emits is essential to an understanding of the Earth's weather and climate. More than half of the U.S. launched meteorology satellites have included instruments to measure this energy. A technique commonly employed in analyzing radiation measurements from radiometers aboard satellites is height rectification, a method whereby an irradiance measurement at satellite altitude is assumed to be proportional to the mean flux over a region within the instrument's Earth field of view.

Previous theoretical studies have sought to determine the accuracy of this technique and to define the size of the region which the measurements best represent. A simulation study is described here which utilizes empirical radiation data from the Nimbus 3 satellite to evaluate the height rectification technique. Irradiance data at satellite altitude are generated over a simulated model of the Earth's long wave radiation field which is based on Nimbus 3 results. Flux densities at the Earth are inferred from the irradiance data and compared to actual flux densities from the model. Unrestricted and restricted field of view flat plate and spherical sensors are evaluated for  $1100 \times 1100 \text{ km}$  regions,  $10^\circ$  latitude zones, and the globe for Lambertian and limb-darkened radiation fields.

## Section of Statistics

Fifty-fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

NONPARAMETRIC SEQUENTIAL TESTS BASED ON WITHIN GROUP RANKING. S. T. Bakir\* and M. R. Reynolds, Jr., Dept. of Statistics, VPI&SU, Blacksburg, VA 24061

For the one-sample location problem groups of  $g$  observations  $(X_{i1}, X_{i2}, \dots, X_{ig}) (i=1, 2, \dots)$  are obtained sequentially.

The critical inequality for the proposed test is  $h_0 < E(SR_i - k) < h_1$ , where  $SR_i$  is the Wilcoxon signed rank statistic computed from the  $i$ th group.  $k, h_0, h_1$  are constants chosen such that the test possesses certain properties. If  $k$  is chosen to be an integer then the test procedure forms a discrete Markov chain  $\{\sum_{i=1}^n (SR_i - k); n=1, 2, \dots\}$

with state space  $\{h_0, h_0+1, \dots, h_1\}$ . Using the theory of Markov chains it is possible to compute exact OC and ASN functions for the test procedure. Two-sample and other tests can similarly be constructed.

STATISTICAL METHODOLOGY UTILIZED IN FORECASTING STATE GENERAL FUND REVENUES. Robert T. Benton, Virginia Department of Taxation, P. O. Box 6-L, Richmond, VA 23282.

Under current law and practice the Governor determines the general fund revenue forecast and has the final responsibility to determine what revenues will be available for appropriation. As a practical matter the Department of Taxation, which collects in excess of 80 percent of general fund revenue, provides the Office of Administration and Finance with staff projections of general fund revenues. These projections are reviewed by an Advisory Board of Economists appointed by the Secretary of Administration and Finance. The Governor reviews the forecast with his Advisory Board on Revenue Estimates composed primarily of business leaders within Virginia. This paper details the methodology utilized by the Department of Taxation in arriving at its projections. It briefly discusses the economic linkages assumed between the Virginia and national economies and discusses in detail the specifications of the forecasting equations utilized to project the four major tax sources of general fund revenue, i.e., the individual and fiduciaries income tax, the state sales and use tax, the corporate income tax, and the public service corporation license tax. Virginia personal income is the primary independent variable utilized in projecting general fund revenues.

COMPLETE RANKING OF RELIABILITY-RELATED DISTRIBUTIONS. T.A. Bishop\* and E.J. Dudewicz\*. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061

In reliability and life testing problems, an experimenter often wishes to rank several populations of items (e.g., devices which serve the same function) in order of "goodness." In many cases it is trivial to decide how to rank the populations, but difficult to decide how many devices of each type to test, and also difficult to evaluate the probability that the ranking is correct. This paper considers these difficult aspects when the basic goodness of a population is simply related to its scale parameter (as is the case for many distributions used in reliability and life testing studies). The techniques provide a guaranteed probability of correct ranking (over usual scale parameter spaces), and in many cases this probability can be evaluated by a Monte Carlo sampling experiment. This furnishes a rational way to choose sample size in reliability and life testing when comparison of competing devices is the basic experimental goal.

HYPOTHESIS COMPOSITION AND RELATED ERRORS VS. DECISION MAKING IN A JURY TRIAL. Edward C. Brindley, Jr. Dept. of Business Administration and Management, Va. Commonwealth Univ., Richmond, Va. 23219

The concept of a test of hypothesis has been compared to the legal process of a jury trial. This pedagogical example serves as a medium to illustrate the errors that are inherent in hypothesis decision making. This paper extends the jury trial analogy to illustrate the basic problem of identifying null and alternative hypotheses. Hypothesis identification problems, which surface in one tailed tests, are of primary significance in hypothesis testing. A jury trial example illustrates the importance of hypothesis construction, which in turn leads to a better understanding of the entire hypothesis testing problem. Until a student understands the fundamentals of hypothesis decision making, the student can never expect to grasp the many different testing situations that build on these fundamentals.



NORMALITY IS NOT A NECESSARY CONDITION. D. R. Jensen and M. A. Chmielewski\*, Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061

Some normal-theory procedures are shown to apply exactly to uncountably many nonnormal distributions. Invariant tests for parameters in the multivariate linear model  $Y = X\theta + E$  are known to be functions of the eigenvalues of a matrix  $U(V'V)^{-1}U'$ . If the distribution of  $E$  belongs to a suitable class of multidimensional elliptically symmetric distributions, it is shown that the null distribution of any invariant test function is the distribution appropriate under normal assumptions, regardless of membership in the class.

SOME PROOFS IN THE NEW ESTIMATION THEORY IN SAMPLE SURVEYS. Anand S. Katiyar. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061

In the past decades some authors explored a few estimators with optimal properties. Hartley, H.O. and Rao, J.N.K. presented an estimator obtained by using the method of maximum likelihood.

In this paper some proofs for results given in the above mentioned paper have been developed for the case when concomitant variable is also considered. The estimator for mean has been compared with the popular regression estimator. The estimate for mean, when mean and variance of an auxiliary variable is apriori known, has been developed.

PERPENDICULAR PROJECTIONS, THE COMPUTER, AND ELEMENTARY STATISTICS. Marvin S. Margolis\*. Dept. of Economics, Virginia Military Institute, Lexington, Va. 24450

By using a few principles of linear vector space theory we can interpret and solve problems in elementary statistics by methods springing from our geometric insights. From the beginning all estimation problems are formulated as equivalent minimum distance problems and are solved by an appropriate application of the projection theorem. The theorems in the paper are expressed as abstractions of intuitive geometric properties of ordinary three-dimensional space. An effort is made to show that the theorems presented are practical in the sense that a computer can calculate the basic results given actual data. The emphasis is on geometric thinking as a means of visualizing and thereby improving our understanding of methods of data analysis and their associated statistical theory.

TESTING TWO COEFFICIENTS OF VARIATION. E. G. Miller, Sch. of Business, VA. Commonwealth University, Richmond, VA 23284

The coefficient of variation is useful in certain instances as a means of comparing the relative variability of two processes. Work by McKay [J. Royal Stat. Society, (1932), 95: 695-698] and Iglewicz [Ph.D. Dissertation, V.P.I., 1967] concerning the sampling distribution of the sample coefficient of variation allows one to construct confidence intervals for or test hypotheses concerning a single population coefficient of variation when sampling from a normal population.

This paper presents a test for the homogeneity of two population coefficients of variation,  $v_i = \sigma_i/\mu_i$ ,  $i = 1, 2$ , where  $\mu_i$  and  $\sigma_i$  are respectively the mean and standard deviation of the two populations. The result is derived using the likelihood ratio procedure and is limited to sampling from two normal populations. Since the distribution of the test statistic is analytically intractable the asymptotic chi square result for  $-2 \ln$  (likelihood ratio) is used for a large sample test. The power of this test is studied using Monte Carlo simulation and an example involving stock prices is given.

PATH ANALYSIS. E. Seneta\* Dept. of Statistics, Australian Nat. Univ., and VA. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Path analysis (P.A.) may be consistently developed in terms of the notion of a best linear predictor for one random variable in terms of a number of others [the residual of such a prediction has zero expectation and is uncorrelated with the predictor variables]. The basic tools for a P.A. are a correlation table of all variables, and a causal scheme (path diagram). The direct causes of each endogenous variable are regarded as its predictor variables, and the residuals added to the diagram as exogenous variables, taking into account possible correlations between all such variables. Matrix methods may be used to check recursiveness, and matrix formulation of correlation structure is possible. Internal consistency may be checked, for a recursive model, in terms of certain zero correlations between pairs of the augmented set of exogenous variables [Kathy Kang, 1971, unpublished]. P.A. emerges as a second-order linear (correlational) analysis of interlocking predictor systems.

MODELING FOREST SPATIAL PATTERNS USING DISTANCE DISTRIBUTIONS. R. F. Daniels\*, Dept. of Forestry and Forest Products, VPI & SU, Blacksburg, VA. 24061.

Quantitative descriptions of forest spatial patterns have become increasingly important in studies of forest regeneration, growth and yield, sampling, and harvesting. Distributions of trees per unit area have been used to describe plot frequencies in quadrat sampling. The Poisson distribution may be derived as the distribution of plot frequencies in a random population. Clumped or aggregated populations have been modeled by the negative binomial distribution. A direct correspondence exists between these distributions and distributions of point-to-plant distances arising in distance sampling. For a random population the exponential distribution describes squared point-to-plant distances. The Pearson type XI distribution may be derived from the negative binomial assumption to describe point-to-plant distances in clumped or aggregated populations. The exponential and Pearson type XI distributions were fitted to observed distances for 40 young loblolly pine stands of seed origin in which clumping was prevalent. Kolmogorov-Smirnov goodness-of-fit tests indicated that the Pearson type XI distribution is better suited as a general spatial model for clumped and random forest stands.

MATRIX CALCULUS IN GENERALIZED MULTIVARIATE LINEAR REGRESSION ANALYSIS. Rana P. Singh, Department of Mathematics, Virginia State College, Petersburg, Va. 23803

The problem of obtaining the estimates of unknown matrix parameters in the multivariate models using matrix derivatives has received the attention of numerous authors. In this paper we consider the regression model of observations  $X$ :

$$X = A\beta + U$$

where  $A:n \times g$  and  $P:h \times p$  are model matrix and fixed matrix respectively,  $\beta:g \times h$  is an unknown parameter matrix,  $U:n \times p$  is a matrix of random errors. We assume that

$$E(U_r) = 0 \quad \text{and} \quad \text{Var}(U_r) = V\sigma^2$$

where  $U_r$  is the row sequenced column vector structure of the elements of  $U$ ,  $V:n \times n$  and  $\Sigma:p \times p$  are positive definite covariance matrices. Matrix differentiation results available in Tracy and Singh [*Sankhyā*, Ser. A, 37, (1975)] are then used to obtain the least squares and maximum likelihood estimates of the unknown matrix parameters  $\beta$ ,  $V$  and  $\Sigma$ . Several particular cases and the advantages of the present method are also cited.

UPPER AND LOWER LIMITS FOR MAXIMUM INBREEDING IN RECURRENT SELECTION. S. Ward, K. Hinkelmann, and C. Genter

Of interest in a recurrent selection program is the change in the coefficient of inbreeding each cycle. Recurrence equations for recurrent selection with successive self-select-intercross cycles have been developed by Cain and Hinkelmann (1970,1972) and Choy and Weir (1976) for random selection and selection for minimum and maximum inbreeding assuming one offspring per mating. The equation for maximum inbreeding is expanded to include 1) the more practical situation of several offspring per mating, 2) recurrent selection without the selfing generation each cycle, and 3) each individual in the intercross generation is involved in only one mating. It is shown that the usual equation for maximum inbreeding is a lower limit and a recurrence equation which gives an upper limit to maximum inbreeding is derived.

## Late Abstract

Fifty fifth Annual Meeting of the Virginia Academy of Science  
May 10-13, 1977, Petersburg, Virginia

SCIENCE RESULTS FROM PROJECT VIKING, George D. Sands, Chief, Scientific & Technical Information Programs Division, NASA Langley Research Center, Hampton, Virginia 23665

Science results are reported from 11 months of observation by the two Viking landers on the surface of Mars.

The wide variety of geological phenomena which have altered the planet are illustrated by selected high resolution color photographs taken on the surface and from orbit.

Results from the 13 Viking science investigations show Mars as a dynamic planet, the study of which will give us a better understanding of our own Earth by using the principle of comparative planetology. Included are findings from the investigations dealing with life detection, chemical analysis of the surface and the atmosphere, meteorology, and seismology.



## NEWS AND NOTES

### ENVIRONMENTAL SCIENCES SECTION TO AWARD PRIZES

The Environmental Science Section of the Virginia Academy of Science shall award two prizes for the best papers presented at the 1978 annual meetings of the VAS and VJAS.

The **Roscoe Hughes Graduate Paper Award** shall go to the best research paper presented by a graduate student. The award carries a certificate and a cash prize of \$40. The letters of intent, including the title of paper and author's name and address, should reach Gilmore Trafford, Office of the Director, NASA Wallops Flight Center, Wallops Station, Virginia 23337 before February 1, 1978. Three copies of manuscripts, limited to 10 double-spaced typed pages (about 3000 words) or equivalent, must reach him before March 1, 1978. Brevity and sufficient precise detail shall be important considerations in the selection. The final selection of the winner and the presentation of the award will be made at the 56th Annual meeting of the Virginia Academy of Science to be held on May 10-12, 1978 at VPI & SU, Blacksburg.

The **Roscoe Hughes Junior Paper Award** shall go to the best paper in any field of the environmental sciences to be presented at the 37th Annual meeting of the VJAS to be held in Blacksburg on May 9-11, 1978. The award, carrying a certificate and \$10 cash prize, shall be presented at the VJAS Awards session on May 11, 1978.

#### JERRI JACK WINS ROSCOE HUGHES AWARD

Jerri L. Jack of Handley High School, Winchester, VA was the recipient of the 1977 Roscoe Hughes Junior Award. Her paper on *The Effect of Topical Acne Agents on Staphylococci* was judged the best paper in environmental sciences presented at the 36th annual meeting of the Virginia Academy of Science held on May 10-11 at Virginia State College in Petersburg, VA. Mrs. Betty Hughes made the presentation of the certificate and \$10 cash prize at the VJAS Awards Session on May 11.

### IN MEMORIUM

#### JESSE BEAMS

Jesse Wakefield Beams, internationally known physicist and professor emeritus at the University of Virginia, died 29 July at the age of 78 in a Charlottesville hospital. Active in research in the fields of biophysics, gravitation and nuclear physics, Beams' instructional and research career spanned more than half a century, most of it at U.VA. In 1974, Beams devised equipment that gave the most accurate known measurement of the constant of gravitation  $G$ .

Dr. Beams was the recipient of the 1967 National Medal of Science for developing high speed centrifuges used to separate the fissionable isotope U 235 from uranium as it is found in nature. Centrifuges designed by Beams have been important tools for protein and virus separations in biological and medical sciences, and for isotope separations in nuclear engineering. His research, started in the early 1940's, has developed into a major part of President Carter's national energy program.

Born December 25, 1898 in Belle Plaine, Kansas, Beams received his B.S. (1921) from Fairmont College, M.S. (1922) from the University of Wisconsin, and Ph.D. (1925) from the U.VA. He began his teaching career at Yale in 1927 and returned to his alma mater in 1928 as associate professor of physics. He was named chairman of the physics department in 1948.

Beams received honorary Sc.D. degrees from the College of William and Mary (1941), University of North Carolina (1946), Washington and Lee University (1949), and Florida Institute of Technology



(1969). His numerous honors and awards include being a member of the National Academy of Sciences, Life Fellow of the Franklin Institute, and Fellow and President (1958-59) of the American Physical Society. He was honored with the Franklin Institute's Potts Medal (1942), U.S. Naval Ordinance Development Award (1946), John Scott Award (1956), American Philosophical Society's Lewis Award (1958), and University of Virginia's Thomas Jefferson Award (1958).

Beams was an active and devoted member of the Virginia Academy of Science, serving as its president in 1947-48. He received the VAS' Meritorious Service Award (now called the Ivey F. Lewis Distinguished Service Award) in 1963, and was elected the Academy Fellow in 1970. Very appropriately, he was named Distinguished Virginian by Governor Holton in 1972.

### CHARLES CLAYTON

Charles Curtis Clayton, 57, a noted biochemist and assistant dean of basic sciences at the Medical College of Virginia of the Virginia Commonwealth University, died following a heart attack on May 14.

A native of Minneapolis, Clayton joined the MCV faculty in 1949, and became full professor and assistant dean in 1964 and 1973, respectively. He held B.S., M.S., and Ph.D. degrees from the University of Wisconsin at Madison.

As a cancer research scientist and a nutritionist, Clayton served as a regular correspondent to *Nutrition Notes*, a publication of the American Institute of Nutrition. He was a member of the New York Academy of Science, the Society for Nutritional Education, and the Virginia Academy of Science.



# PAPERS TO APPEAR IN THE FALL 1977 ISSUE

## ARTICLES

- Photoelectrolytic Decomposition of Water by Solar Energy—A Possible Source of Fuel. *Aaron World*, Brown University, Providence, Rhode Island
- Distribution and Habitat of the Cotton Rat (*Sigmodon hispidus*) in Central Virginia. *John F. Pagels*, Virginia Commonwealth University, Richmond, Virginia
- Depth-Dose Relations for Heavy Ion Beams. *J. W.*

*Wilson*, NASA Langley Research Center, Hampton, Virginia

## NOTES

- Polydactyly in *Myocastor Coypus*. *Gale R. Willner* and *Joseph A. Chapman*, Center for Environmental and Estuarine Studies, University of Maryland, Frostburg, Maryland

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4. Biology
5. Chemistry
6. Materials Science
7. Engineering
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12. Statistics
13. Space Science and Technology
14. Botany
15. Environmental Sciences

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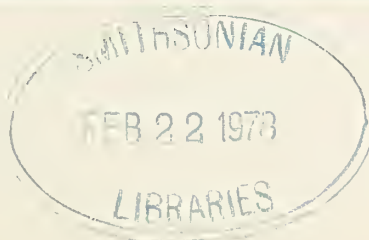
# VIRGINIA JOURNAL OF SCIENCE

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## DOLLARS AND SENSE

D. Rae Carpenter, Jr.  
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Delma Rae Carpenter, Jr., professor of physics and director of research laboratories at Virginia Military Institute received his B.S. (1949) Roanoke College, M.S. (1951) Cornell University, and Ph.D. (1957), U. VA. He has extensive instructional and research experience in physics combined with a broad spectrum of administrative and professional activities. He is Chairman of the Board of Trustees of the Science Museum of Virginia and of the VAS Committee on Finance and Endowment. He is a member of the Sigma Xi, Sigma Pi Sigma and Phi Society, and the American Association for the Advancement of Science elected him a Fellow in 1966. For his long and dedicated service, the VAS honored its past president with election as Fellow in 1973 and with the Distinguished Service Award in 1976.

The Virginia Academy of Science has completed its 55th year. For a volunteer organization, meeting only once a year, such longevity is a tribute to the membership. We must be doing something right! Yet it makes sense for us to carefully examine how our dollars are spent for Academy programs.

These programs fall into three major categories: Junior Academy, Virginia Journal of Science, and membership services, including the annual meeting.

The Junior Academy, organized in 1951, serves as a forum for high school students to present papers judged by senior scientists for monetary awards, provided through the courtesy of Philip Morris, in each of 11 sections. It is consistently one of the most active and successful junior scientist programs in the nation. Credit for this performance goes to our committee of senior members whose enthusiastic and dedicated support deserves our greatest encouragement.

The Virginia Journal of Science, which accounts for about 40 percent of our expenditures, serves as our living history in the publication of abstracts, news of sections, and actions of Council. In addition, it fills the role of a professional journal for all the sciences, but it is especially appropriate for those papers of statewide or regional interest in biology, botany, and agricultural and environmental sciences. It needs our support in soliciting advertising statewide. These revenues are of great importance because current printing costs approximately equal the dues paid by each member.

Membership services and annual meeting costs require the smallest part of our budget. Our Secretary-Treasurer is paid part time but devotes many additional hours of his service to the Academy. Committee activities are a significant component of this portion of the budget. The Flora Committee has been responsible for collecting numerous speci-



mens, and it provides small amounts to a number of members to assist them in collecting. The Research Committee annually awards \$1,500 to \$2,000 in amounts of several hundred dollars each based on competitive proposals submitted by Virginia scientists.

It goes without saying that the Academy exists to serve the needs of science and scientists in Virginia, and it can only be effective in so doing if it has the support of the scientific community, industrial and governmental as well as academic. The Academy needs every member to assist in his own way, be it in soliciting new members, Journal advertising, serving on committees, working with high school students or whatever is "your own thing."

While it might appear that organizations such as the Academy exist primarily through dues, this is perhaps less true of this organization than of many others. Our funds are not used for travel or incidental expenses for officers or committee members. The value of time contributed by scientists for Academy work is many times our annual budget. Endowment gifts support the annual lectureship, the research program and provide general fund income. These gifts have often come from our most involved members.

The scientific community might well agree that the golden age of science was in the 60's, particularly in the Federal support provided to a broad range of organizations and individuals. But our dedication as scientists must not cease here. If the Academy is to continue to provide a service to the scientific community, it must seek new ways for this service to be effective. It must be alert to new programs, to new opportunities for fund raising, and to new ways to serve students and those just entering the profession as well as that ever increasing segment of older scientists retiring from active careers.

As we review our prior support of the Academy and as we face the future, certain areas of service seem appropriate for special mention. The life blood of the annual meeting lies in the quality of the papers presented. It is our responsibility to solicit annually from our colleagues and our students fuller meeting participation. We often hear that the Academy is not as prestigious a forum as the national professional societies, yet we fail to recognize the great value of a state meeting for communication among our colleagues of the kinds of research activity conducted on our very doorstep. The young people in our colleges are given recognition and valuable training in the presentation of papers before an audience composed of their peers and senior scientists interested in their advancement. Those members of the Academy who have been involved in our visiting scientist program or who have worked with the high school students recognize the tremendous opportunity for senior scientists to be of service to Virginia's secondary schools. They have also experienced the satisfaction of conveying their enthusiasm, their interests and their dedication to their profession to the hundreds of young people who have not yet decided upon a career. While we do not expect to make scientists of all of them, we should expect that they would leave their schools with a better appreciation and a better understanding of the scientific world in which they will be living.

The Academy and the world in which it finds itself have changed greatly over this half century. With your help the Academy can continue as the voice of science in Virginia, providing service to its members and to our younger scientists, advice to state government and, most importantly, supplying the vehicle for communication among the members of the scientific community. It all depends on YOU.

# Photoelectrolytic Decomposition of Water by Solar Energy— a Possible Source of Fuel

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(Received March 21, 1977; Revised July 18, 1977)



Aaron Wold, professor of Chemistry. Received Ph.D. (1952), Polytechnic Institute of Brooklyn. Principal research interest: crystal chemistry of transition metals. Has written over 115 papers on relationship between crystal chemistry and physical properties of transition metal oxides, chalcogenides, and pnictides. Negus Memorial Lecturer, 55th VAS annual meeting.

**Abstract**— Several oxides, e.g.  $\text{TiO}_2$ ,  $\text{SrTiO}_3$ ,  $\text{SnO}_2$ , and  $\text{WO}_3$ , have been used as anodes for the photoelectrolytic decomposition of water by solar energy. It has been observed that all of these oxides must be made conducting by the creation of oxygen defects. However, oxygen deficiencies undoubtedly are responsible for the long-term instability of the electrodes studied to date. An alternate method of enhancing conductivity is by chemical substitution of oxygen by fluorine. The absence of oxygen vacancies should result in the formation of more stable electrodes towards oxygen in solution. Previous investigations have shown that water decomposition, using only an n-type semiconductor anode, is not efficient, but that cells with two photosensitive electrodes, i.e. an n-type anode and a p-type cathode, may be used as sources of electrical energy and perhaps even for the efficient photoelectrolytic decomposition of water by solar energy.

## Introduction

A viable source to replace fossil fuels for the production of unlimited energy, without pollution of the environment, may be the photoelectrolysis of water. The scheme, first proposed by Fujishima and Honda (1972) involves the decomposition of water into hydrogen and oxygen by photoelectrochemical processes. The method involves the absorption of light by semiconducting electrodes with the subsequent production of electron-hole pairs. The latter are then separated by the semiconductor-electrolyte junction

and injected at the cathode and anode to produce reduction and oxidation reactions, respectively. As a result, hydrogen can be formed at the cathode by the combination of electrons with hydrogen ions from the electrolyte, and oxygen is produced at the anode by the combination of the electrolyte with holes. This process is shown in Figure 1.

Fujishima and Honda (1972) made use of n-type semiconducting  $\text{TiO}_2$ . Unfortunately, the band gap of  $\text{TiO}_2$  is 3 eV, which was insufficient to produce hydrogen and oxygen in the photoelectrolysis cell used without an external anodic bias of about 0.3 to 0.5 V. Furthermore, 3 eV corresponds to an absorption edge of about 4000 Å. Since only 3 to 5 percent of the solar spectrum is distributed at wavelengths less than 4000 Å, photoelectrolysis using  $\text{TiO}_2$  electrodes is inefficient.

There are several physical properties of a semiconductor which must be optimized in order to obtain a plausible candidate for a photoanode. They are chemical stability, band gap, work function and conductivity. The semiconducting anode must be inert to a strongly oxidizing environment. Useful anode materials must be able to sustain the high oxidation potential of the oxygen half cell ( $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- = 2\text{H}_2\text{O}$ ,  $E_0 = 1.23$  V). As a result, many semiconducting pnictides and chalcogenides cannot be used as satisfactory electrodes.

In order for decomposition of water to occur, energy in excess of 1.23 volts must be applied. Consequently, the semiconductor must have a band gap of at least 1.23 volts. To optimize the absorption efficiency of the semiconductor under solar radiation, the band gap must match closely the maximum solar output of the sun (approximately 1.6 eV) (Pankove 1971).

The work function of a semiconductor is the energy difference between a bound electron at the Fermi level and a nonassociated electron in vacuum. This value defines the absolute energy of the electrons in a semiconductor. When an electrode is immersed in an electrolyte, an exchange of electrons may occur between the semiconductor and the electrolyte only if the work function at the surface of the semiconductor corresponds energetically to the energy of the hydrogen-oxygen half cells. Finally, the semiconductor must be capable of conducting a current in order for



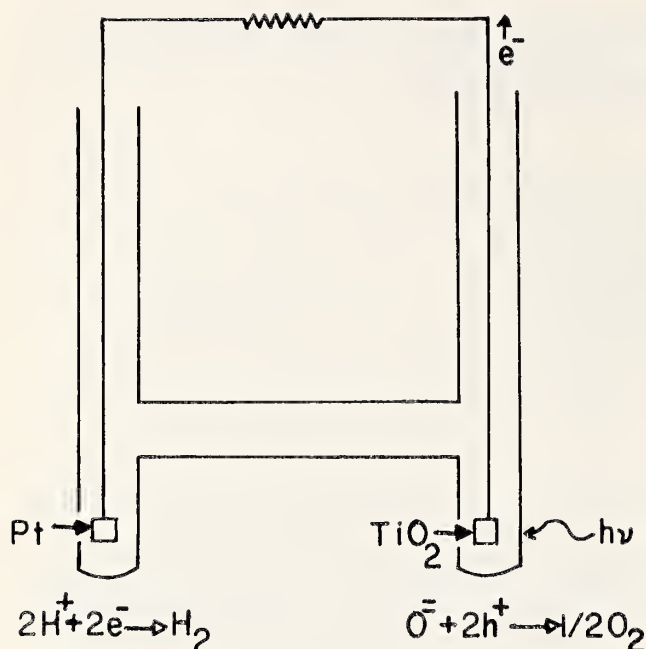


FIG. 1—Photoelectrolysis of water.

the cell to function. Therefore, semiconductors with a resistivity range of  $10^{-1}$  to  $10^4$  ohm-cm are usually used as anodes.

In addition to many reported studies on  $\text{TiO}_2$  electrodes,  $\text{SnO}_2$  (Wrighton et al. 1976),  $\text{WO}_3$  (Hodes et al. 1976),  $\text{SrTiO}_3$  (Mavroides et al. 1976) and  $\text{BaTiO}_3$  (Nasby and Quinn 1976) (Schleich et al. 1977) have also been investigated to determine their possible use as anodes for the photodecomposition of water by solar energy. All of these materials are broad band semiconducting oxides which have been reported to be chemically stable. Of all these materials only  $\text{SrTiO}_3$  has shown spontaneous photodecomposition of water. However, it has a poor solar collection efficiency because of its relatively broad band gap (3.4 eV).

### Generation of a Photopotential

Manassen et al. (1976) have discussed what takes place when a semiconductor is brought into contact with an electrolyte solution and then illuminated. Figures 2a-c show the electron energy levels across the semiconductor electrolyte interface. When an n-type semiconductor is in a vacuum, the energy levels may be represented by Figure 2a. Figure 2b shows what occurs when the semiconductor is immersed in an electrolyte solution having a redox potential of  $E_{\text{redox}}$ . It should be noted that Figure 2b represents the plot of the energy levels after thermodynamic equilibrium has been achieved, i.e. the electrochemical potential in both phases is equal. In order to compare the redox potential with the same energy scale used for the semiconductor, both are referred to the energy level of an electron in vacuo at infinity ( $E_{\text{vac}}$ ). The  $\text{H}^+/\text{H}_2$  redox couple is 4.5 eV below that of  $E_{\text{vac}}$ . It should be emphasized that the phenomenon of photoelectrolysis is primarily a surface

effect occurring at the solid-liquid junction; therefore, questions arise as to the exact mechanism responsible for photoelectrolysis.

It was assumed by Manassen et al. (1976) that the surface states do not have a role in determining the energetics of the electrolyte-semiconductor interface. What is assumed is that equilibrium will be attained by the movement of the majority carriers (electrons) from the semiconductor to the solution. There is then a redistribution of positive and negative charge carriers at and near the surface until the Fermi level of the solid equals the redox potential of the solution. This is shown in Figure 2b by a bending of the valence and conduction bands towards the semiconductor surface forming the surface charge layer (SCL). The illumination of the n-type anode with radiation having an energy content greater than the optical band gap of the semiconductor ( $E_g$ ) leads to the energy plot shown in Figure 2c. The Fermi level of the semiconductor is no longer equal to the redox potential of the electrolyte solution. If the n-type anode is now connected to a platinum electrode, which serves as the cathode, a photopotential  $V$  is established between the two electrodes, which is shown in Figure 3.

Manassen et al. (1976) also showed that an energy balance for absorbed photons ( $h\nu > E_g$ ) can be made in a photoelectrolysis cell. In such a working, corrosion-free cell, the energy balance can be composed of the following units:

$$\begin{aligned} (1) \quad h\nu &= E_c - E_v \\ &= (E_{\text{redox}} - E_v) + (E_f - E_f [\text{photo}]) \\ &\quad + (E_c - E_f) + iR + \eta_c + \eta_p + V \\ (E_c - E_v) &= \text{difference in energy between the} \\ &\quad \text{conduction band and the valence band.} \\ (E_{\text{redox}} - E_v) &= \text{difference in energy between the} \\ &\quad \text{potential of the redox couple and} \\ &\quad \text{the valence band.} \\ (E_f - E_f [\text{photo}]) &= \text{difference between the Fermi} \\ &\quad \text{level in vacuum and the Fermi} \end{aligned}$$

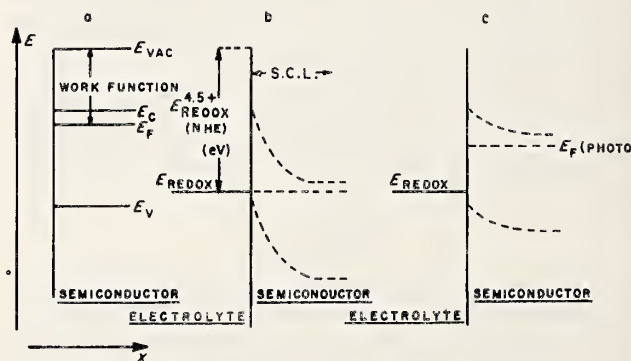


FIG. 2—Plots of energy levels: a, n-type semiconductor in vacuo; b, n-type semiconductor/electrolyte in the dark; c, n-type semiconductor/electrolyte, when illuminated. SCL: space charge layer;  $E_c$ : bottom of conduction band;  $E_v$ : top of valence band;  $E_{\text{vac}}$ : energy level of electron in vacuum;  $E_f$ : Fermi level;  $E_{\text{redox}}$ : Redox potential of electrolyte; NHE: normal hydrogen electrode;  $E_f(\text{photo})$  Fermi level of illuminated electrode.

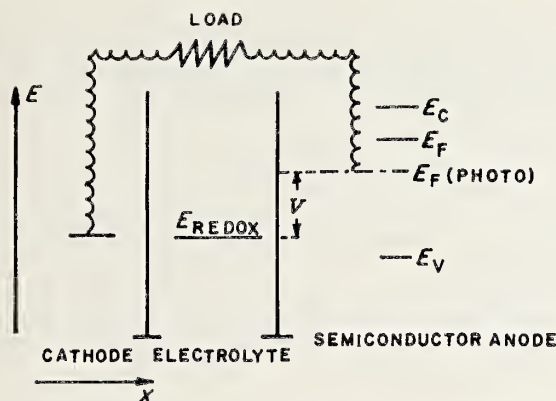


FIG. 3—Schematic illustration of the photopotential ( $V$ ) obtained in a photoelectrochemical cell. The relative positions of  $E_c$ ,  $E_r$ ,  $E_r(\text{photo})$  and  $E_v$ , from Fig. 1 are indicated.

level in contact with electrolyte under illumination.

$(E_c - E_r)$  = difference in energy between the conduction band and the Fermi level.

$iR$  = resistance losses in the system.

$\eta_c$  = overpotential at the counter electrode.

$\eta_p$  = overpotential at the photoelectrode.

$V$  = photopotential established between the two electrodes.

The assignment of conservative values to each of the items in the above equation resulted in the following equation:

$$(2) \quad h\nu = E_c - E_v = V + 1 \text{ eV}$$

It appears that if the assignments made by Manassen et al. (1976) are correct, then the difference between the obtainable photopotential and the optical band gap of the semiconductor is at least one eV in a working photoelectrochemical cell.

For cells in which a platinum counter electrode is used as the cathode and an n-type semiconductor as the anode, there are several important consequences resulting from equation (2). For a semiconductor which will allow optimal utilization of the solar energy ( $\sim 1.4$  eV) the maximum photopotential attainable is only  $\sim 0.4$  eV. If the aim is to decompose water,  $V > 1.23$  eV, then the band gap of the semiconductor must be greater than 2.23 eV. Therefore, to decompose water into hydrogen and oxygen it must be realized that an important part of the solar spectrum, i.e.  $\lambda > 550$  nm, may be unusable.

A possible solution to the problem is to use an n-type semiconductor photoanode and a p-type semiconductor photocathode in which two photopotentials,  $V_c$  and  $V_a$  (see Figure 4) are obtained which are additive (Manassen et al. 1976). If a combination of an n-type and a p-type semiconductor is used, both must be exposed to sunlight. It must also be remembered that such a cell is possible only if the work function of the n-type anode can be matched with that of the hydrogen half-cell potential via band bending. Similarly the work function for the p-type

electrode can be matched with the oxygen half-cell potential.

### Improved Stability of n-type Anodes

The development of stable compounds which would have a better matching between the energy gap with the solar spectrum is of prime importance. Most of the oxides which have served as n-type electrodes in previous studies were made oxygen deficient to increase their conductivity. There is a question of the long-term stability of these oxygen-deficient materials under strongly oxidizing conditions. An alternate method of enhancing conductivity in these compounds is by the chemical substitution of oxygen by fluorine. From the vast literature dealing with the tungsten and molybdenum bronzes it is certainly possible that fluorine may be substituted for oxygen resulting in the formation of compounds of the type:  $M^{II}W_{1-x}^{VI}W_x^{VO}O_{4-x}F_x$  or  $M^{II}Mo_{1-x}^{VI}Mo_x^{VO}O_{4-x}F_x$ . The absence of oxygen vacancies should result in the formation of more stable electrodes (towards oxygen in solution), and the substitution of transition metals for  $Ca^{++}$  or  $Mg^{++}$  should result in marked decreases in the band gaps.

### Summary

It is possible to improve the present efficiencies and stabilities of electrodes useful for the photoelectrolytic decomposition of water by one or both of the following approaches:

1. Continuing to search for stable compounds which would have a better matching between the optical band gap with the maximum energy obtained from the solar spectrum.
2. Utilizing an n-type semiconductor photoanode and a p-type semiconductor photocathode which are both stable and whose work functions are reasonably matched with the hydrogen and oxygen half-cell potentials.

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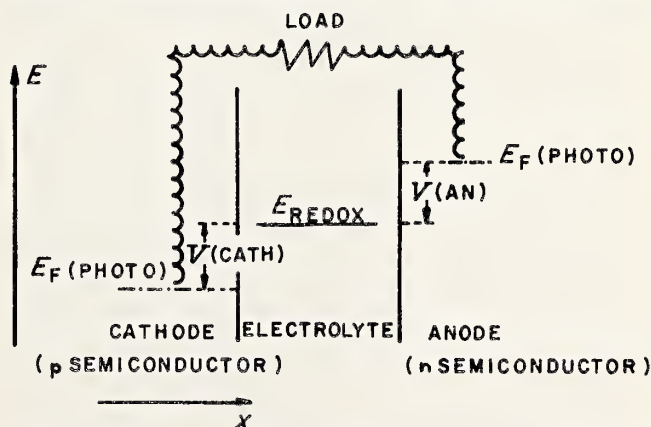


FIG. 4—A schematic illustration of the photopotential obtainable when a combination of a photoactive n-type anode and a photoactive p-type cathode is used.



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### Literature Cited

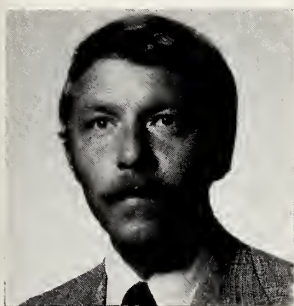
- Fujishima, A., and K. Honda. 1972. Electrochemical photolysis of water at a semiconductor electrode. *Nature* **238**:37-38.
- Hodes, G., D. Cahen, and J. Manassen. 1976. Tungsten oxides as a photoanode for a photoelectrochemical cell (PEC). *Nature* **260**:312-313.
- Manassen, J., D. Cahen, and G. Hodes. 1976. Electrochemical, solid state, photochemical and technological aspects. *Nature* **263**:97-100.
- Mavroides, J. G., J. A. Kafalas, and D. F. Kolesar. 1976. Photoelectrolysis of water in cells with  $\text{SrTiO}_3$  anodes. *Appl. Physics Letters* **28**:241-242.
- Nasby, R. D., and R. K. Quinn. 1976. Photoassisted electrolysis of water using  $\text{BaTiO}_3$  electrodes. *Materials Res. Bull.* **11**:985-992.
- Pankove, J. I. 1971. *Optical process in semiconductors*. Prentice-Hall, Englewood Cliffs, New Jersey.
- Schleich, D. M., C. Derrington, W. Godek, D. Weisberg, and A. Wold. 1977. Semiconducting properties of barium titanate and iron substituted barium titanate. Accepted by the *Materials Res. Bull.*
- Wrighton, M. S., D. L. Morse, A. B. Ellis, D. S. Ginley, H. B. Abrahamson. 1976. Photoassisted electrolysis of water by ultraviolet irradiation of an Antimony doped stannic oxide electrode. *J. American Chem. Soc.* **98**:44-48.

# DISTRIBUTION AND HABITAT OF COTTON RAT (*SIGMODON HISPIDUS*) IN CENTRAL VIRGINIA

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**Abstract**— The hispid cotton rat, *Sigmodon hispidus*, is reported from several new localities in central Virginia. The northernmost site is in Powhatan County just south of the James River. Cotton rats were captured north of the James River in southeastern Henrico County. Old fields in the grass-shrub stage that contain dense shrubby growth, especially honeysuckle (*Lonicera japonica*), seem to be the preferred habitat of the cotton rat in central Virginia.

The hispid cotton rat, *Sigmodon hispidus*, is found in a variety of grass-shrub habitats in tropical America and northward into the south-central United States (Handley and Patton 1947; Hall and Kelson 1959). The reports by Patton (1941) and Lewis (1944), and later by Pagels and Adleman (1971), of northward range expansion by the cotton rat in Virginia are similar to numerous observations of range expansion in the central and western states (Rinker 1942; Cockrum 1948; Jones 1960; Mohlenrich 1961; Genoways and Schlitter 1967). Many investigators have noted the apparent sensitivity of the cotton rat to cold-related stresses (Dunaway and Kaye 1961; Goertz 1964; Fleharty et al. 1973; Kirksey et al. 1975). Pagels and Adleman (1971) sampled several localities in central Virginia but captured *S. hispidus* at only one site in Chesterfield County and suggest that this population is the remnant of a greater overall movement that has been arrested, possibly as a result of factors related to low temperatures.

This research provides new locality records since the Pagels and Adleman (1971) report, reporting additional areas in central Virginia where *S. hispidus* has been taken. Some information is presented on the habitat utilized by *S. hispidus* in Virginia. Cotton rats from localities extending from the upper Coastal

Plain to the higher Piedmont in central Virginia, comprising more than 160 catalogued specimens, are deposited in the Virginia Commonwealth University Mammal Collection.

Most sampling consisted of spot trapping in various field communities that included large fields, vacant lots, and highway and railway rights-of-way. In many instances transects were established that encompassed both grassy and shrubby portions of the areas sampled. Relatively extensive sampling in peripheral sites to those recorded here (the western portions of Powhatan and Henrico counties and the counties of Goochland and Hanover) has not yielded cotton rats. Cotton rats were collected to the southwest in Appomattox County and Amelia County in fall 1976. Lewis (1940) collected cotton rats throughout Amelia County and did not find *S. hispidus*.

Marginal records of captures of *S. hispidus* are given in Figure 1. The northernmost known locality of *S. hispidus* in Virginia is in north-central Powhatan County, 0.4 mi south of the James River. Additional specimens were taken south of this site, 1.7 and 6.0 mi from the James River. I have collected cotton rats at eight localities in Chesterfield County since 1970, including Presquile, a man-made island in the James River just south of the Henrico County and Charles City County line (Jackson et al. 1976). I collected *S. hispidus* north of the James River at three localities near Varina in eastern Henrico County. The Varina records are of greater significance than the more northerly Powhatan County localities since they demonstrate that the animal has crossed the river and could now increase the northern and western extent of its range in Virginia.

As already mentioned, cotton rats are apparently sensitive to severe winter conditions. Severity of winter conditions in central Virginia, including temperature extremes and the duration of stressful periods, is less than in areas of Nebraska where *S. hispidus* is now found (Genoways and Schlitter 1967; Farney 1975). The mean January temperature for Kearney County, Nebraska, the northernmost locality (Farney 1975) for *S. hispidus*, is  $-3.8^{\circ}\text{C}$ , and the mean number of frost-free days is 159 (Blair 1941). The mean January temperature for Powhatan County, Virginia (Hibbard 1941) is approximately  $3.3^{\circ}\text{C}$ , and the mean number of frost-free days, 198. Some cli-



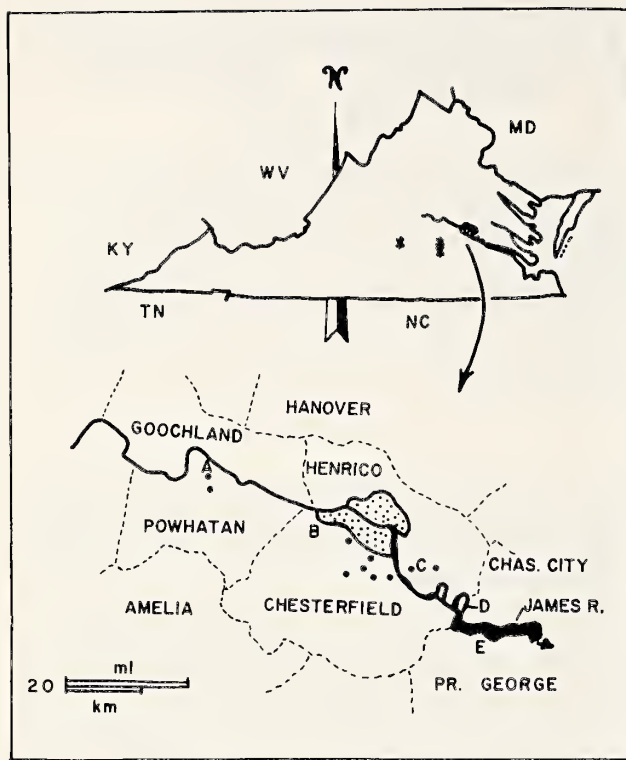


FIG. 1—Sites where *Sigmodon hispidus* has been collected in central Virginia. Marginal records are (A) Powhatan Co., (Rt. 522) 0.4 mi S of James River (by Rt. 313); (B) Chesterfield Co., Bon Air; (C) Henrico Co., Varina; (D) Chesterfield Co., Presquile National Wildlife Refuge; (E) Prince George Co., 7.4 mi E Hopewell (on Rt. 10). Asterisks indicate the sites of recent captures in Amelia County — \* — 2.2 mi N, 1 mi W, Amelia Courthouse, and 4.4 mi N, 1 mi W, Amelia Courthouse; and Appomattox County — \* — 3 mi E Appomattox River (from Holliday Lake State Park) near Prince Edward County line. Dots indicate other capture sites, and stippled area designates the City of Richmond.

matic features from near the northeastern and northwestern extent of the range of *S. hispidus* in Virginia are presented in Table 1. Since severity of winter conditions probably determines range expansion in *S. hispidus*, comparison of climatic information from Virginia and Nebraska and within Virginia (Table 1) suggests that *S. hispidus* could increase its range northward in Virginia.

In all captures of *S. hispidus* in Virginia, I have found a close link between the presence of cotton rats and the presence of viny-shrub growth. Goertz (1964) and Fleharty and Mares (1973) observed that as a rule *S. hispidus* utilizes old field habitat with tall and dense vegetation regardless of geographic variation in species composition. In central Virginia, Japanese honeysuckle (*Lonicera japonica*) and certain other plants (e.g. trumpet creeper, *Campsis radicans*) with similar growth forms provide suitable habitat. Only in late summer, when grasses and weedy plants (such as *Aster* and *Solidago*) and legumes (including *Lespedeza*, *Cassia*, and *Vicia*) are tall, dense, and supplement patchy shrub growth, have I found cotton rats very far from patches of honeysuckle. Honeysuckle is in part evergreen, and the vines and foliage provide nearly 100 percent cover from above throughout most of the year. When cuttings or detritus within honeysuckle patches indicate feeding by cotton rats, vines of honeysuckle are also important food items. In late winter, in areas of concentration of cotton rats, honeysuckle cuttings sometimes form nearly complete mats. A variety of other mammals utilize this kind of habitat. Handley and Patton (1947) noted that the golden mouse (*Ochrotomys nuttalli*), the masked shrew (*Sorex cinereus*), and the southeastern shrew (*S. longirostris*) are often taken in habitats that include considerable amounts of honeysuckle. Wright and Pagels (1977) caught *S. hispidus*, as well as *Microtus pennsylvanicus*, *Reithrodontomys humilis*, *Peromyscus leucopus* and *Mus musculus* in

TABLE 1  
Selected climatic data for the northernmost (Richmond area) and northwesternmost (Appomattox County) extent of the range of *Sigmodon hispidus* in Virginia. Numbers in parentheses indicate years of weather records

	RICHMOND			APPOMATTOX		
Lowest daily temperature	Dec	Jan	Feb	Dec	Jan	Feb
maximum — °C	-5.5	-11.0	-7.2	-5.0	-12.8	-6.1
minimum — °C	-17.2	-18.3	-16.1	-15.5	-18.9	-16.6
	(26)			(14)		
Annual $\bar{X}$ No. days with temperature below 0°C	79.8			100.2		
	(25)			(10)		
Extreme year	1960, 100 days			1969, 116 days		
Annual $\bar{X}$ No. days with temperature not above 10°C	68			74		
	(25)			(11)		
Extreme year	1958, 92 days			1972, 94 days		
Annual $\bar{X}$ No. days with snowfall greater than 2.54 cm	3.9			4.3		
	(29)			(28)		
Extreme year	1966-1967, 9 days			1968-1969, 11 days		

traps setup off the ground in patches of honeysuckle.

Kirksey et al. (1975) and Wright and Pagels (1977) noted that man may have played an important role in the northern expansion of the range of *S. hispidus* along the east coast by creating a suitable habitat, for example by logging activity and later by the abandonment of cultivated areas. Wright and Pagels (1977) further suggested that man's role may have been enhanced by the introduction of Japanese honeysuckle. Because of the abundant suitable habitat available and the aforementioned climatic considerations, and because the cotton rat has crossed the James River, it appears that *S. hispidus* will continue to expand its range in Virginia. In the future the animal should be searched farther northeast of its present range and in additional areas of the higher Piedmont in the southern and western portions of the State.

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### Literature Cited

- Blair, T. A. 1941. Climate of Nebraska. In: Climate and Man, Yearbook of Agriculture. U.S. Dept of Agriculture, Washington, D.C. pp. 967-978.
- Cockrum, E. L. 1948. The distribution of the hispid cotton rat in Kansas. Trans. Kansas Acad. Sci. 51:306-312.
- Dunaway, P. B. and S. V. Kaye. 1961. Cotton rat mortality during severe winter. J. Mamm. 42:265-268.
- Farney, J. P. 1975. Natural history and northward dispersal of the hispid cotton rat in Nebraska. Platte Valley Rev. 3:11-16.
- Fleharty, E. D. and M. A. Mares. 1973. Habitat preference and spatial relations of *Sigmodon hispidus* on a remnant prairie in west-central Kansas. Southwestern Nat. 18:21-29.
- Fleharty, E. D., M. E. Krause, and D. P. Stinnett. 1973. Body composition, energy content, and lipid cycles of four species of rodents. J. Mamm. 54:426-438.
- Genoways, H. H. and D. A. Schlitter. 1967. Northward dispersal of the hispid cotton rat in Nebraska and Missouri. Trans. Kansas Acad. Sci. 69:356-357.
- Goertz, J. W. 1964. The influence of habitat quality upon density of cotton rat populations. Ecol. Monogr. 34:159-181.
- Hall, E. R. and K. P. Kelson. 1959. The mammals of North America. The Ronald Press Co., New York. 2:viii + 547-1083 + 79.
- Handley, C. O., Jr. and C. P. Patton. 1947. Wild mammals of Virginia. Commonwealth of Virginia. Comm. of Game and Inland Fisheries. vi + 220 pp.
- Hibbard, F. H. 1941. Climate of Virginia. In: Climate and Man, Yearbook of Agriculture. U.S. Dept of Agriculture, Washington, D.C. pp. 1159-1169.
- Jackson, R. S., J. F. Pagels, and D. N. Trumbo. 1976. The mammals of Presquile, Chesterfield County, Virginia. Va. J. Sci. 27:20-23.
- Jones, J. K., Jr. 1960. The hispid cotton rat in Nebraska. J. Mamm. 41:132.
- Kirksey, E. R., J. F. Pagels, and C. R. Blem. 1975. The role of the tail in temperature regulation of the cotton rat, *Sigmodon hispidus*. Comp. Biochem. Physiol. 52A:707-711.
- Lewis, J. B. 1940. Mammals of Amelia County, Virginia. J. Mamm. 21:422-428.
- Lewis, J. B. 1944. Cotton rat in lower Piedmont Virginia. J. Mamm. 25:195.
- Mohlenrich, J. S. 1961. Distribution and Ecology of the hispid and least cotton rats in New Mexico. J. Mamm. 42:13-24.
- Pagels, J. F. and R. G. Adleman. 1971. A note on the cotton rat in central Virginia. Va. J. Sci. 22:195.
- Patton, C. P. 1941. The eastern cotton rat in Virginia. J. Mamm. 22:91.
- Rinker, G. C. 1942. An extension of the range of the Texas cotton rat in Kansas. J. Mamm. 23:439.
- Wright, D. E. and J. F. Pagels. 1977. Climbing activity in the hispid cotton rat, *Sigmodon hispidus*, and the eastern meadow vole, *Microtus pennsylvanicus*. Chesapeake Sci. 18:87-89.



# Depth-Dose Relations for Heavy Ion Beams\*

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**Abstract**— Radiation transport of heavy ions in matter is of interest to radiological protection in space and high-altitude aircraft. In addition, heavy ion beams are expected to be of advantage in radiotherapy since their characteristic Bragg curve allows a relative reduction of the dose in reaching a tumor site and the near elimination of exposure beyond the tumor region as the beam exits the body. Furthermore, the radioresistance of tumorous cells due to their hypoxic state may be reduced or eliminated by the high specific ionization of heavy ion beams. The depth-dose distribution of heavy ion beams consists of energy deposited by the attenuated primary beam with its characteristic Bragg curve and a relatively unstructured background due to secondary radiations produced in nuclear reactions. This is an accurate picture for the light ions ( $z < 6$ ). As the ion mass increases, the secondary contribution becomes more structured and may add significantly to the Bragg peak of the primary ions. The result for heavy ions ( $z > 20$ ) is a greatly broadened Bragg peak region, especially in comparison to straggling effects, which may prove to be of importance in radiotherapy and biomedical research.

## Introduction

Radiation transport of energetic ions in matter is a problem of interest for the development of radiation protection in space, high-altitude aircraft, and accelerator facilities. In addition, it is presently thought that heavy ion radiation therapy may have an advantage over conventional X-ray or  $\gamma$ -ray therapy due to the near absence of exit dose (dose delivered beyond

the tumor site), the relative reduction of entrance dose (dose delivered in reaching the tumor site), and the reduction or possibly complete elimination of the oxygen effect (tumor cells are normally radiation resistant due to their hypoxic state). Fundamental to radiation protection and therapy are the processes by which an ion beam imparts energy to extended matter and the corresponding determination of depth-dose distributions.

It is generally regarded that the depth-dose distribution consists of the energy deposited by the attenuated primary beam with its characteristic Bragg curve and a less structured background due to secondary radiations produced in nuclear reactions (Wilson and Khandelwal 1974; Raju et al, 1974). In the case of proton or alpha beams of interest for therapeutic purposes (energy near or below 300 MeV/amu), such a description is indeed useful since the Bragg curve of the primary beam is clearly distinguished near the end of its range (Turner et al. 1964; Litton et al, 1968), with little interference from secondary radiations.

As the mass of the beam ion becomes large ( $z \gg 10$ ), the Bragg curve of the primary beam will come to play a lesser role even in the peak region. This follows from the observation that the stripping of a few to several nucleons from the ion is a preferred nuclear reaction. Such secondary ions produce Bragg curves which strongly overlap the Bragg curve of the primary beam, causing a coalescence of peaks near the range of the primary ions. It will be our purpose here to examine these effects and to make some estimates of depth-dose curves on the basis of available nuclear parameters.

## Theory

We consider a simplified theory of ion transport in which angular dispersion is neglected, secondary fragments produced in nuclear reaction are assumed to have the same velocity as the fragmenting parent nucleus, and electromagnetic interaction is treated in a continuous slowing-down model (Wilson 1977). Furthermore, energy dependence of the nuclear reaction parameters is ignored. The resulting transport equations are given by:

$$\left[ \frac{\partial}{\partial x} - \frac{1}{A_j} \frac{\partial}{\partial E} S_j(E) \right] \phi_j(x, E) = -\sigma_j \phi_j(x, E) + \sum_k m_{jk} \sigma_k \phi_k(x, E) \quad (1)$$

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where  $\phi_j(x, E)$  is the flux of ions of type  $j$  moving to the right at  $x$ , and  $E$  is the ion kinetic energy in units of MeV/amu;  $\sigma_j$  is the corresponding macroscopic cross section;  $S_j(E)$  is the energy deposited by the ion per unit path length due to collision with orbital electrons; and  $m_{jk}$  is the probability of producing a type  $j$  ion in a collision of a type  $k$  ion with the transport medium nuclei. The solution of equation (1) for a unit fluence of primary type  $J$  ions of energy  $E_0$  normally incident on a slab of material can be approximated by using perturbation theory (Wilson 1977; Wilson and Lamkin 1975) and the first two contributions to the dose corresponding to surviving primaries and first generation secondaries (i.e., in the summation of equation (1) we retain only the  $k = J$  terms) and is given by

$$D_J(x) \approx S_J[R_J^{-1}(R_0 - x)] \exp[-\sigma_J x]$$

$$+ \sum_{j=1}^{J-1} m_{jJ} \sigma_j \frac{z_j^2 A_J}{z_J(z_J - z_j)} [E_{uJ} - E_{LJ}] \exp(-\bar{\sigma}_j x) \quad (2)$$

$$\text{where} \quad R_J(E) = A_J \int_0^E dE' / S_J(E') \quad (3)$$

$$R_0 = R_J(E_0) \quad (4)$$

and  $R_J^{-1}$  is the inverse function of  $R_J(E)$ . The quantities  $E_{uJ}$  and  $E_{LJ}$  bound the range of energies allowed for a type  $j$  ion at a depth  $x$ . Using the approximation

$$z_k R_k(E) = z_J R_J(E) \quad (5)$$

results in

$$E_{uJ} = R_J^{-1} \left[ \frac{z_J}{z_j} R_0 - x \right] \quad (6)$$

and

$$E_{LJ} = R_J^{-1} \left[ \frac{z_J}{z_j} (R_0 - x) \right] \quad (7)$$

The  $\bar{\sigma}_j$  in equation (2) is calculated as if all of the secondaries at  $x$  were produced at a point located at one half the distance traveled by a primary beam. Hence,

$$\bar{\sigma}_j = \begin{cases} \sigma_j \frac{R_0}{2x} + \sigma_j \left(1 - \frac{R_0}{2x}\right) & x \geq R_0 \\ \frac{1}{2} \sigma_j + \frac{1}{2} \sigma_j & x \leq R_0 \end{cases} \quad (8)$$

The error introduced in the attenuation factor by this approximation is small for the results presented herein since heavy ion reactions predominantly result from the stripping of a few nucleons from the ion nucleus for which  $\sigma_j \approx \sigma_j \approx \bar{\sigma}_j$ .

If the energy difference in equation (2) is expanded about  $z_J \approx z_j$  as

$$E_{uJ} - E_{LJ} \approx S_J[R_J^{-1}(R_0 - x)] \cdot \frac{(z_J - z_j)}{A_J z_J} x + O \left[ \frac{(z_J - z_j)^2}{z_J^2} \right] \quad (9)$$

then the dose may be approximated by

$$D_J(x) \approx S_J[R_J^{-1}(R_0 - x)] \exp(-\sigma_J x) + \sum_{j=1}^{J-1} m_{jJ} \sigma_j S_J[R_J^{-1}(R_0 - x)] X \exp(-\bar{\sigma}_j x) \quad (10)$$

Although equation (10) tends to show the secondary dose contributions in the Bragg region explicitly, the expansion (9) does not converge near the Bragg peak and fails entirely beyond the range of the primary ions. One has from equation (10) a simple physical interpretation since the expression

$$\phi_j(x) \approx m_{jJ} \sigma_J \times \exp(-\bar{\sigma}_j x) \quad (11)$$

is seen to be the lowest order approximation to the  $j$ th secondary ion flux. Clearly, the more accurate result given by equation (2) must be used for dosimetric studies.

Presently, we have taken the macroscopic cross section as

$$\sigma_j \approx 0.0123 z_j^{2/3} \text{ (cm}^{-1}\text{)} \quad (12)$$

which reasonably represents the actual data (Wilson and Costner 1975) for type  $j$  ions in tissue. The fragmentation probabilities are taken from Rudstam's formula for fragmenting ions on hydrogen targets with Waddington's modifications (Waddington 1969). The use of fragmentation parameters on hydrogen targets as a first approximation for tissue targets is justified by the observed weak dependence of ion fragmentation on the target material (Heckman 1975).

## Results

The depth-dose distribution (dose averaged over 1 mm steps in thickness) for Mn ions of 492 MeV/amu is calculated from equation (2) with Waddington's version of fragmentation and cross sections given by equation (12) and is shown in Figure 1. In the peak region, only 37 percent of the primary beam remains with the other 63 percent being converted into secondary ions. A coalescing of secondary particle Bragg

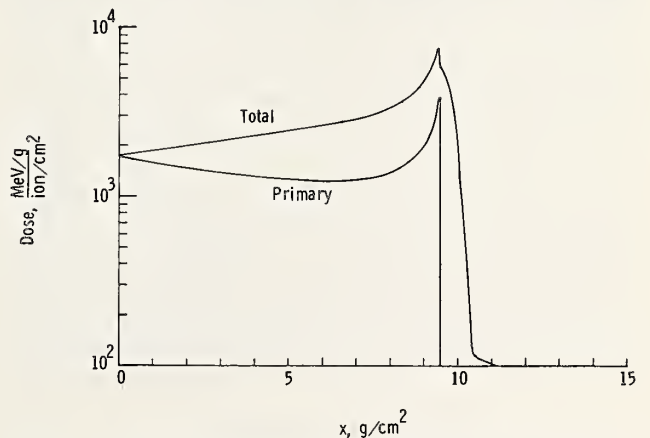


FIG. 1—Depth-dose distribution of 492 MeV/amu Mn ions in tissue.



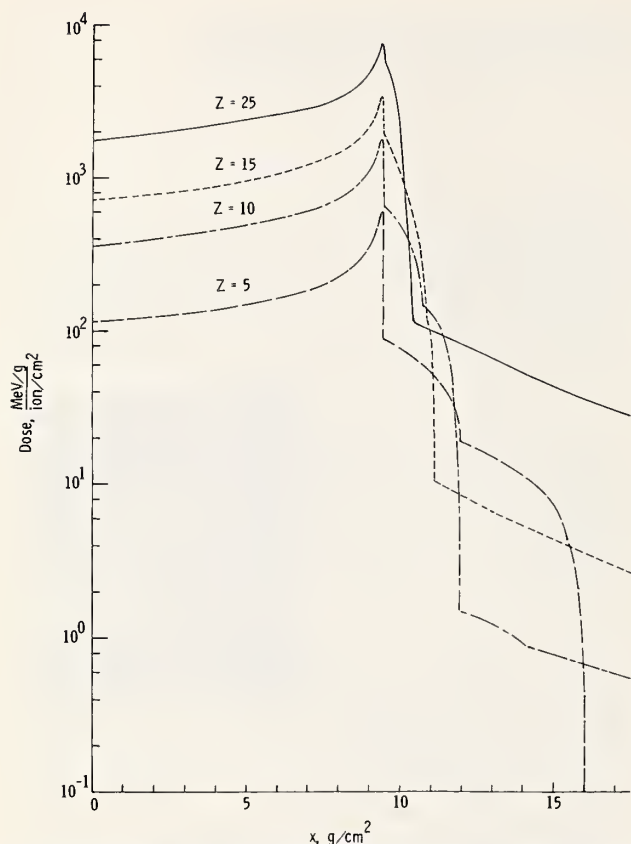


Fig. 2—Depth-dose distributions of several ions in tissue. Range of primary ions is 9.5 g/cm<sup>2</sup> for each case.

peaks is caused by the fact that the removal of a few nucleons from a heavy ion nucleus does not greatly alter its range-energy relations. This coalescing of secondary particle Bragg peaks near 10 cm is clearly apparent.

Depth-dose profiles for several ions are shown in Figure 2. The initial energy was chosen in each case so that the primary ion's range was 9.5 g/cm<sup>2</sup>. The secondary ion contributions for various secondary charge groups are clearly distinguished for the  $z = 5$  and 10 ion beams by the cascading shoulder curves to

the right of the primary beam's Bragg peak. Each successive shoulder represents the removal of one additional charge unit from the ion nucleus which results in an increase in range as approximated by equation (5). The terminator location of each shoulder can be related to the primary ion's range by equation (5).

### Concluding Remarks

It has been demonstrated that an understanding of the dosimetry of heavy ion beams requires an intricate knowledge of the nuclear reactions of the ions with the target material. Although some insight as to the modification of the depth-dose profiles by nuclear processes has been gained, a definitive determination must await the estimation of the higher-order terms in the perturbation series and a general improvement in our understanding of the nuclear fragmentation process.

### Literature Cited

- Heckman, H. H., 1975. Heavy ion fragmentation experiments at the BEVATRON semiannual progress report on NASA grant NGR 05-003-513, N75-72927.
- Litton, G. M., J. Lyman, and C. A. Tobias. 1968. Penetration of high-energy heavy ions, with the inclusion of coulomb, nuclear, and other stochastic processes. UCRL-17392.
- Raju, M. R., J. T. Lyman, and C. A. Tobias. 1974. Particle irradiation methods. Chapter 3 in *Space Radiation Biology and Related Topics*, ed. C. A. Tobias and P. Todd. Academic Press, p. 115.
- Turner, J. E., C. D. Zerby, R. L. Woodyard, H. A. Wright, W. E. Kinney, W. S. Snyder, and J. Neufeld. 1964. Calculation of radiation dose from protons to 400 MeV. *Health Phys.* **10**, 783.
- Waddington, C. J. 1969. The fragmentation of cosmic ray nuclei in interstellar hydrogen. *Astrophys. and Sp. Sci.* **5**, 3.
- Wilson, J. W. 1977. Analysis of the theory of high-energy ion transport. NASA TN D-8381.
- Wilson, J. W. and C. M. Costner. 1975. Nucleon and heavy ion total and absorption cross section for selected nuclei. NASA TN D-8107.
- Wilson, J. W., and G. S. Khandelwal. 1974. Proton dose approximation in arbitrary convex geometry. *Nucl. Technol.* **23**, 298.
- Wilson, J. W., and S. L. Lamkin. 1975. Perturbation theory for charged particle transport in one dimension. *Nucl. Sci. and Eng.* **57**, 292.

# RADIORESPIROMETRY: A FAST SCREENING PROCEDURE FOR TESTING EFFECTS OF POLLUTANTS IN MAMMALS

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Rumuli Iltis, electronic engineer. Received B.S.E. and MSEE, University of Cincinnati. Holds 3 patents and publications in biomedical and electronic sciences. Current research interests: biomedical engineering, systems analysis, and mathematical modeling.



Robert G. Miller received B.S. (chemistry-biology), Eastern Kentucky University. Member of Board, College of Environmental Control Technology, University of Cincinnati. Current research interests: lipid and tissue chemistry, trace metals.



George Sanzone, associate professor of chemistry. Received B.S. (engineering physics), M.S. (chemistry) and Ph.D. (chemical physics), University of Illinois. Current research interests: chemical kinetics (molecular beams and shock tubes) and mass spectrometry.

**Abstract**— A compartmental analysis for the radiorespirometric study of the metabolism of  $^{14}\text{C}$ -glucose in mammals is described. The model is applied to the study of the effects of  $\text{CH}_3\text{HgCl}$  on this metabolism. Implications of the agreement between the experiment and the mathematical model for the development of fast-screening experiments for detecting *in vivo* effects of pollutants and toxins are discussed.

## Introduction

Radiorespirometric studies have successfully explained the effects of metabolic conversion of  $^{14}\text{C}$ -labeled substrates to  $^{14}\text{CO}_2$  and the influence of various factors on metabolism (Dost et al. 1973; Tolbert et al. 1956). This method allows one to make observations without the need for sacrificing the subjects of the observations. In addition, an animal can be used as its own control, and the cumulative effects of repeated dosing can also be studied. However, the technique requires the acquisition of large quantities of data in order to arrive at statistically meaningful conclusions. Radiorespirometry has been applied to the determination of the effects of pollutants (Lee et al. 1972; Wang 1967). Prior to such detailed studies, however, there is a need for "fast-screening" experiments to provide a rapid indication that a toxic problem exists.

In this paper, a fast prescreening procedure is proposed which makes use of mathematical modeling. With this procedure, the need for detailed toxicological studies can be predicted from small sets of data. The modeling method should provide a convenient, rapid and inexpensive screening technique for ingested toxins or pollutants which have an effect on the excretion pattern for  $^{14}\text{C}$ .

## Experimental Data

Experimental design, detailed methodology, theoretical considerations, and related background infor-



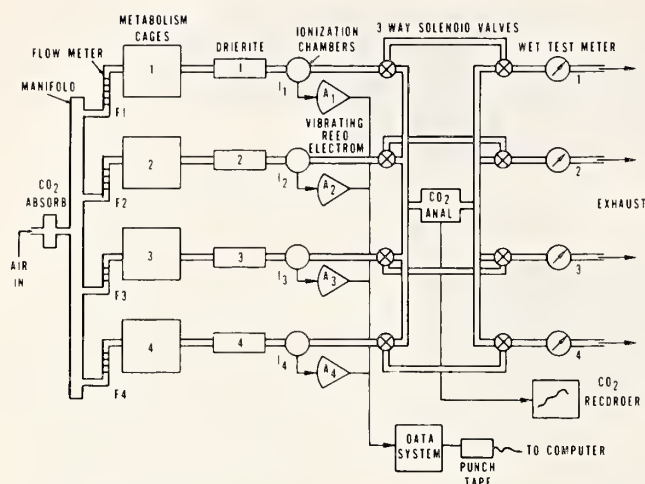


FIG. 1—Radiorespirometer Block Diagram.

mation have previously been reported (Tolbert et al. 1956; Lee et al. 1972; Wang 1967). Expired radio-carbon dioxide was continuously monitored with ionization chambers via Cary vibrating-reed electrometers. Analog data from these electrometers were digitalized, stored on paper tape, and then decoded on a PDP8-I computer. The block diagrams of the system are shown in Figures 1 and 2. The decoded data used in our modeling studies came from two independent experimental studies (from the laboratory of S. D. Lee, U.S. EPA, Cincinnati, Ohio).

The first series of experiments employed 16 Charles River rats, each acting as its own control by having its  $^{14}\text{CO}_2$  excretion measured in the radiorespirometer prior to the application of the toxic substance investigated. The control conditions were that each rat fasted 24 hours before the study, received 100 mg glucose per kg body mass via gavage one hour prior to study, and was injected with 1- $^{14}\text{C}$ -glucose (20  $\mu\text{Ci}$  per kg body mass) via tail vein at the beginning of the radiorespirometric study. The 16 rats were then divided into 4 groups and tested exactly 1 week later under the same experimental parameters. Group A acted as an additional control; Groups B and C were administered via gavage 1 and 5 mg, respectively,

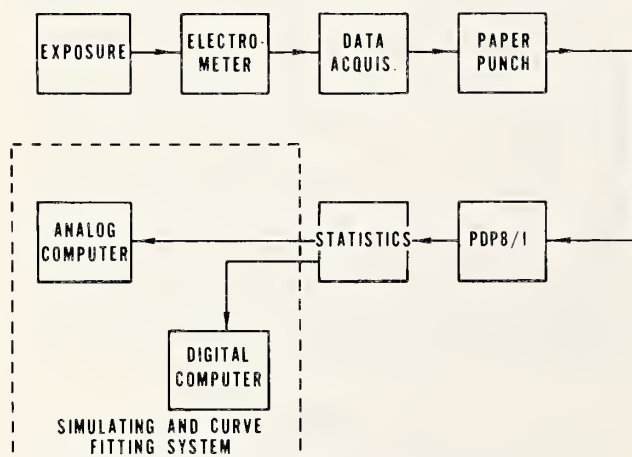


FIG. 2—Data Handling System.

methylmercury(II) chloride, 24 hours prior to testing; Group D was fasted every other day.

The second series of experiments employed 16 rats: 8 Charles River and 8 Sprague Dawley. These were divided into four groups, two rats from each vendor to a group. The rats maintained their assigned chambers in the radiorespirometer in both experiment series. The control conditions for the second series were identical to those of the first. The 16 rats were then divided into 4 groups and tested exactly 1 week later under the same experimental parameters except that the rats were fasted every other day with a 48-hour fast prior to study; 24 hours before respirometry (i.e. before  $^{14}\text{C}$  injection), each rat received 0.05 mg methylmercury(II) chloride per kg body mass via gavage. Data for each group was taken as the average response of the four rats within that group.

### Compartmental Analysis

A compartmental model for the radiorespirometry experiment has been developed and employed to simulate the effects of the toxicant  $\text{CH}_3\text{HgCl}$  on the metabolism of glucose (see Figure 3).

It is assumed that a two-pool open system exists (Shipley and Clark 1972) in which the blood pool is the central compartment while the second pool is a conglomerate of peripherals (kidneys, liver, lungs, etc.). Peripheral pools can communicate only through the central compartment. If we ignore the dead space in the respiratory tract, the lung can be considered as composed of two classical compartments (Riley 1965): the gas-exchange compartment L, and the anatomical dead space in the alveoli A. The model is based upon the biological fact that blood is a vehicle by which the effect of an ingested toxicant ( $\text{CH}_3\text{HgCl}$  in this study) is superimposed on all other peripherals, thus influencing the  $^{14}\text{C}$  excretion pattern. Each compartment is assumed to follow first-order kinetics in that the  $^{14}\text{CO}_2$  loss rate is taken to be proportional to the number of moles of  $^{14}\text{CO}_2$  within the compartment. Actually, the excretion from the blood pool is not linear (Piotrowski 1971); but, when steady-state kinetics apply,

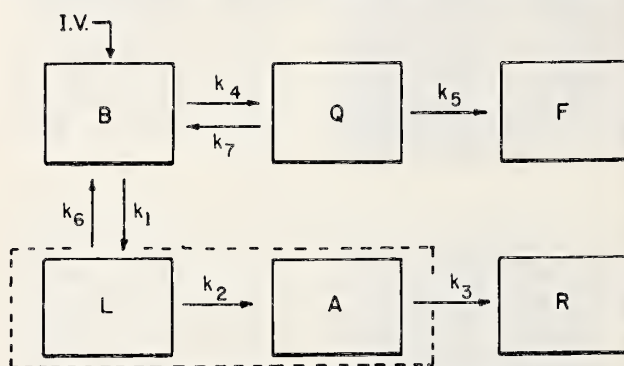


FIG. 3—A Compartmental Model for Radiorespirometry.

A = alveoli dead space  
B = blood  
F = feces and urine  
L = lung blood-gas exchange region  
Q = other storage organs  
R = respired air

the blood pool can also be treated as a classical compartment (Aris 1966).

If A, B, F, L, Q, and R represent the moles of  $^{14}\text{C}$  in the alveoli, blood, feces (and urine), lung, other organs, and respired air, respectively, then the mass balance for  $^{14}\text{C}$  can be written:

$$A + B + F + L + Q + R = \text{constant} \quad (1)$$

The model given in Figure 3 can be represented by a set of five first-order differential equations and the condition of mass balance:

$$\frac{dR}{dt} = \dot{R} = k_3 A$$

$$\frac{dA}{dt} = k_2 L - k_3 A$$

$$\frac{dL}{dt} = k_1 B - (k_2 + k_6) L \quad (2)$$

$$\frac{dB}{dt} = k_6 L + k_7 Q - (k_1 + k_4) B$$

$$\frac{dQ}{dt} = k_4 B - (k_5 + k_7) Q$$

The observed quantity in a radiorespirometric study is actually  $\dot{R}$ ; the solution for this quantity takes the form:

$$\dot{R} = \sum_{i=1}^4 c_i \exp(-\lambda_i t), \quad (3)$$

where  $\{c_i, \lambda_i\}$  are constants which depend upon both the toxic agent and the animal under study. At the start of the experiment,  $t = 0$  and

$$\sum c_i \equiv 0. \quad (4)$$

The constants in equations (3) and (4) are determined with measurements of  $^{14}\text{C}$  respiration rate made at the beginning of an experiment.

The above analysis was tested against data from eight groups of animals (four animals per group). Both analog and digital computers were employed. Figure 4 indicates the agreement between the data and the model.

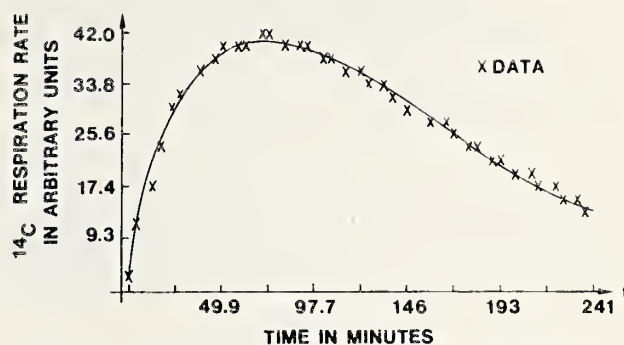


FIG. 4—Comparison between experimental data and model computation. First Experimental Sequence, Group B—Exposed.

### Summary of Results

The total or cumulated  $^{14}\text{CO}_2$  respired is obtained by integrating the respiration rate  $\dot{R}$ :

$$R(t) = \int_0^t \dot{R} dt \quad (5)$$

A standard radiorespirometric measure of the effect of a toxin is the difference ( $\Delta$ ) in cumulative  $^{14}\text{CO}_2$  respired between control and exposed animals (Lee et al. 1972; Wang 1967). Table 1 presents a comparison of experimental and simulated values of  $\Delta$  for both series of experiments at a time 145 minutes after injection of the radiolabeled glucose. In particular, we note that total  $^{14}\text{C}$  recovered by respiration decreased substantially for animals exposed to methylmercury(II) chloride.

The agreement between the predictions of the model and the experimental data is acceptable for a fast-screening procedure. It even suggests that it is possible to predict biological effects of a pollutant or toxicant under specific conditions by computer simulation and interpolation. Once an adequate response function has been determined, data from a very limited set of experiments should permit reasonable first predictions of the results of a more detailed study.

The application of our compartmental model to prescreening the effects of toxicants requires a bare minimum of 14 very reliable measurements (7 for the control group and 7 for the exposed group). By in-

TABLE 1  
Percent Cumulative Respired  $^{14}\text{CO}_2$  After 145 Minutes\*

Experiment	Group	Experimental Results			Compartmental Analysis		
		Control	Exposed	$\Delta$	Control	Exposed	$\Delta$
First	A	65.08	61.64	3.44	66.17	60.56	5.61
	B	71.04	48.58	22.46	72.50	49.00	23.50
	C	61.56	55.97	5.59	62.95	57.74	5.21
	D	66.17	60.27	5.90	65.21	58.4	6.81
Second	100	40.30	30.80	9.50	40.30	—	—
	101	41.47	27.81	13.66	42.51	29.85	12.66
	102	44.30	31.43	12.87	43.34	33.26	10.08
	103	57.44	28.90	28.54	58.30	31.03	27.27

\* Note: The time of 145 minutes was chosen arbitrarily.



roducing additional approximations, this minimum basis set of measurements can be reduced. For example, the results for exposure and control experiments with  $\text{CH}_3\text{HgCl}$  can be very precisely fitted with a two-parameter model of the form:

$$\dot{R} = B_1 t \exp(-B_2 t) \quad (6)$$

Constants  $B_1$  and  $B_2$  were evaluated during the first 10 to 20 minutes of an experiment. Using this fitting function, only four reliable measurements would be necessary to predict the entire radiorespirometry results for a given toxin or pollutant.

#### Acknowledgments

We wish to acknowledge the help of S. D. Lee whose laboratory provided the data used to test our model. Helpful comments of R. Rover were also appreciated.

#### Literature Cited

- Aris, R. 1966. Compartmental analysis and the theory of residence time distribution in intracellular transport, K. B. Warren, ed. Academic Press, New York.
- Dost, F. M., D. E. Johnson, and C. H. Wang. 1973. Aerospace Medical Research Laboratory Report AMRL-TR-73-33. Wright-Patterson AFB, Dayton, Ohio.
- Lee, S. D., K. C. Butler, R. M. Danner, L. McMillan, W. Moore, and J. F. Stara. 1972. American Laboratories, 8.
- Piotrowski, J. 1971. The application of metabolic and excretion kinetics to problems of industrial technology. U. S. DHEW.
- Riley, R. L. 1965. Gas exchange transportation. *In*: Physiology and Biophysics, T. C. Ruch and H. D. Patton, eds. W. W. Saunders Co., London, pp. 771-777.
- Shipley R. A., and R. E. Clark. 1972. Tracer methods for *in vivo* kinetics. Academic Press, New York.
- Tolbert, B. M., M. Kirk, and E. M. Baker, 1956. American J. Physiol. 185, 269.

# POLYDACTYLY IN MYOCASTOR COYPUS

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(Received May 26, 1977; Revised July 22, 1977)



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Joseph A. Chapman, associate professor and head, Appalachian Environmental Laboratory. Ph.D. (1970), Oregon State University. Principal research interests: mammalian ecology, reproductive physiology, and biology of introduced mammals. Author: three monographs and several papers in mammalogy and ecology. Associate editor, Chesapeake Science.

The nutria, *Myocastor coypus*, is a large South American histricomorph rodent which has been widely introduced into North America and parts of Europe. Although there have been a number of publications concerning the control and ecology of nutria, relatively few papers have been published on morphology. Schitoskey (1971) reported on anomalies of nutria skulls and dentition, but did not discuss polydactyly. According to Winchester (1958), polydactyly is an uncommon but inherited condition.

The purpose of this note is to report on polydactyly found in a male and a female nutria. Both nutria were trapped on Blackwater National Wildlife Refuge, Dorchester County, Maryland, the male on October 24, 1975, and the female on October 9, 1976. Both nutria were tagged and released. Both hind feet of both nutria had six toes (Fig. 1). In January 1977 the female was killed and turned over to project person-

nel by a local trapper. Of 1047 nutria taken from the same location over a 4-year period, these were the only 2 showing a 6-toe anomaly.

External measurements (mm) of the female nutria were total length, 870; tail length, 355; hind foot length, 121; ear length (notch), 26; and weight (g), 3505. The skin and skull of the female are housed in the Museum of the Appalachian Environmental Laboratory (AEL #957). External measurements (mm) of the male taken in the field were total length, 905; tail length, 385; hind foot length, 128; ear length (notch), 25; and weight (g), 4026.

This is Contribution No. 772-AEL, Center for Environmental and Estuarine Studies, University of Maryland, and a contribution of Maryland Federal Aid in Wildlife Restoration Project W-49-R.

## Literature Cited

- Schitoskey, F. 1971. Anomalies and pathological conditions in the skulls of nutria from southern Florida. *Mammalia* 35(2):311-314.  
Winchester, A. M. 1958. *Genetics*. Houghton Mifflin Co., Boston. 414 pp.

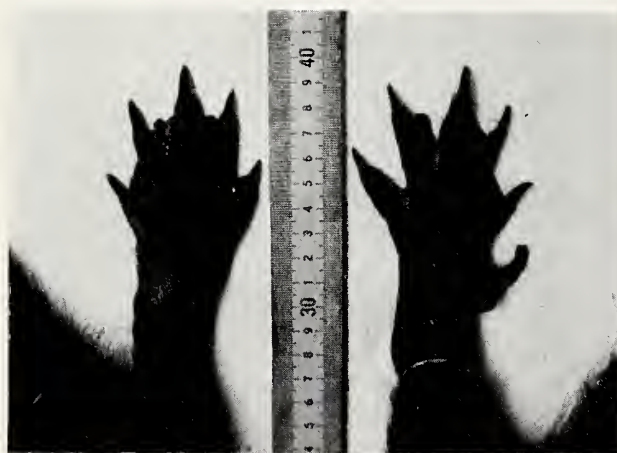


FIG. 1. Photograph of hind feet of two nutria. A normal nutria foot is on the left. The abnormal foot of a female nutria (AEL #957) is on the right.



## SCIENCE AND SOCIETY

## Governor Advised on Science Matters Affecting the Commonwealth

At the time the Commonwealth of Virginia was faced with the Kepone contamination problem, Governor Mills E. Godwin requested Dr. Arthur Burke, the President of the Virginia Academy of Science to recommend three scientists who could assist the Governor on science matters affecting the Commonwealth of Virginia. On February 9, 1976, the Governor appointed this Committee consisting of Dr. Herbert McKennis, professor and head of biochemical pharmacology at MCV; Dr. Ertle Thompson, professor of science education at the University of Virginia; and Dr. Kuldip P. Chopra, professor of physics and geophysical science (environmental and space physics). The Laetrile question is the second major issue on which he consulted his science advisers. On October 13, 1977, he released to the press this committee's report which is reproduced below:

Within the last 18 months the smoldering controversy about whether or not Laetrile is effective in the treatment of cancer has been fanned to flaming intensity. At the present moment, it does not appear that the controversy will soon subside. If, for some reason, Laetrile is proven to be of lasting value, the controversy may wane. Alternatively, in a few years, Laetrile may be forgotten just as was its predecessor Krebiozen, which had no success in establishing itself firmly as an approved drug.

Since the literature has been extensively catalogued elsewhere, no attempt will be made to do that here. To give perspective to the report, however, an appendix is provided. This appendix includes, largely through newspaper clippings, some reference to the scientific literature and provides some aspects of public opinion in various areas outside of Virginia where Laetrile use has achieved varying degrees of legal sanction.

Because there is public interest in the use of Laetrile which is being used in Virginia or by Virginia citizens who travel to Mexico or parts of the United States where Laetrile is more generally available, the question arises as to whether or not Laetrile use should and could be facilitated in Virginia. To some, the important question is, assuming that the Laetrile is a tremendous hoax and that the public must be protected from itself and Laetrile promoters, how can further use of Laetrile be discouraged or even prohibited in Virginia?

Personal views of the undersigned on some of these problems have been assembled. Although no immediate solution to the Laetrile controversy is seen by any of us, such reflections as we have made may serve in some small measure to indicate areas in which partial solutions may be achieved. Too, there

are a number of alternatives. The first of these would be for the Commonwealth of Virginia to take no special action with respect to Laetrile at the present time.

In the event that no special governmental action is taken in Virginia, there will probably continue to be some use of Laetrile by Virginia citizens, as previously noted, with and without medical supervision. Consideration of this possibility by various groups has led to the suggestion that legislation be enacted to permit cancer patients to receive Laetrile legally at their specific request and under medical supervision—providing also that other means of treatment have been determined to be fruitless and that the disease is considered terminal. As part of such proposed legislation, physicians would be protected against malpractice liability for using or condoning use of Laetrile. Although there seems to be no legal restriction against the use of any substance when the physician deems it best even if patient gratification is the sole result, *lack of federal sanction or listed approval of a drug creates a vulnerability to malpractice suits* and other uncomfortable situations for the physicians.

Some lay groups, although recognizing the principle that people who are about to die in any event should be permitted the psychological comfort of a drug that is not proven to be effective, feel that any loosening of legal restrictions may open the door to many substances of no proven effectiveness. Henceforth, according to this view, pressure groups would arise for all types of drugs, and the way would be clear for the reintroduction of a variety of nostrums.

In opposition to this point of view, which is accepted in part, there arises the argument that despite some increased availability of nostrums and their use, there will be an increased field testing of new drugs to the advantage of the public. Only in the marketplace does a drug show its real worth or lack of worth. According to this argument then, the general public, if accurate and sufficient records are kept, will discriminate between what is bad and what is good. The good then survives, and the bad does not receive acclaim. A broad determination is made—one that can not be made under present circumstances by official Washington, including the Food and Drug Administration and the National Cancer Institute.

Some components of the organized medical groups that are associated with the American Medical Association and the Medical Society of Virginia appear to recognize this principle and would be willing on request of terminally ill patients to treat them with Laetrile after first making it clear to the patients that

Laetrile is definitely of unproven value and possibly might have harmful effects. *The voices of such physicians will probably not be publicly heard to any great degree.*

In response to the strong argument that favors the limited use of Laetrile, there is the caution that *Laetrile is not a fully defined substance*. Laetrile sometimes means amygdalin, and sometimes there is no amygdalin in Laetrile. When Laetrile does contain amygdalin the amount is variable, and other substances in Laetrile vary in number and concentrations.

To circumvent the indefinite composition of Laetrile, it has been proposed that Laetrile be manufactured within state borders to avoid interstate jurisdiction of the Food and Drug Administration, which presently considers Laetrile promotion a fraudulent scheme and resists court decisions permitting personal transportation of Laetrile under a physician's prescription. Knowledgeable people long familiar with the Food and Drug Administration predict that *any local manufacture of Laetrile will cause the FDA to charge engagement in interstate commerce on the grounds that paper in the labels, detergents used to clean apparatus, or other materials used in the Laetrile production line come from out of state.*

*In summary, it can be stated that Laetrile, although not a drug of proven value, probably never can be a drug of no proven value. It is virtually impossible to prove a substance useless under any and all conditions. This is especially true of cancer where there are scores*

*of types and variations of the disease which make it presently impossible to conduct a total clinical test under fully controlled conditions.*

If Laetrile does not prove itself effective during the course of several years, use of Laetrile may gradually decline to the near zero point as has been the case with other of our medical customs, including the use of stomach brushes and related quaint items. Under these circumstances, common sense will have prevailed without the enactment of any new legislation. This in the long run may be the most expedient and useful route.

Signed: Herbert McKennis (1)  
Ertle B. Thompson (2)  
Kuldip P. Chopra (3)  
August 1977

- (1) Professor of Pharmacology and Head, Division of Biochemical Pharmacology, Medical College of Virginia.
- (2) Professor of Science Education, University of Virginia.
- (3) Professor of Physics and Geophysics, Old Dominion University.

Affiliations, (1), (2), and (3) are supplied for identification only.

The signatories are acting as scientific advisers to Governor Godwin by his appointment as nominees of the Virginia Academy of Science and are expressing their own opinions.

## FEATURES

### Book Review

#### Seamanship: A Handbook for Oceanographers

*Carvel H. Blair*

227 pp. Cornell Maritime Press, Inc., Cambridge, Md. \$9.00

It appears that far too often the seagoing scientist finds he is little more than a passenger on a cruise for which he may be a principal investigator, simply due to a lack of knowledge of seamanship or an appreciation for the mechanics of the equipment he must rely upon for data acquisition. Captain Blair has undertaken to provide a basic handbook, written in lay terms, which will provide the beginner with the basic nomenclature of ships and small craft, equipments, basic deck seamanship and boat handling and basic navigation without the depth or technicality of a Knight or Bowditch.

Any reader, particularly an experienced sailor, will find any number of things he believes ought to have been included, but were not. The book is aimed at the beginner and from that standpoint does an admirable job of addressing those areas of seamanship in which oceanographers will most likely become involved early in their seagoing careers. The subjects are presented in easily understood language. Where a new concept or term is used, the author is careful to explain it and its usage. Perhaps one of the more attractive features of the book is the emphasis placed on the practical application which can be encountered. Except in a small craft doing inshore work, the beginner will rarely be called upon to assume the role of master or ship's navigator, but it is essential that he have an understanding and appreciation of the problems inherent in operating a vessel and be prepared to intelligently plan and execute out a mission. It is in this area that *Seamanship, A Handbook for Oceanographers* would have its greatest value to the beginner. The author also addresses some subjects which are rarely covered in similar books, such as the trailering, launching and recovering of small craft and a very practical chapter on living and working aboard a research vessel.



In covering 17 major topics such as small boat handling, power plants, rules of the road, hazards and aids to navigation, electronic and celestial navigation, tides and currents, weather and communications, many subjects are of necessity addressed in a cursory fashion, sometimes only with a brief paragraph. However, in those instances where further study would be necessary to fully understand a particular subject, the author has provided the appropriate references. There are also appendixes which contain additional references, and a list of addresses of organizations and manufacturers which can be used as a source for further information on equipments, charts, boats, and communications.

Although the book is intended to serve as a handbook for oceanographers, it would serve equally well any one who goes to sea in connection with their profession. It is a very readable book, which will provide a student or beginning oceanographer with sufficient background to permit their embarking on a research vessel prepared to speak the language and contribute to an overall effort.

John G. McMillan (Com., USN)  
*Oceanography Department*  
*U. S. Naval Academy*  
*Annapolis, MD*

## Profile

### Psychology Section

The Psychology Section of the Virginia Academy of Science was one of four original components of the Academy in 1923. Starting with 18 charter members, it was originally called the Section of Psychology and Education.

Over a span of four decades prior to 1976, several changes in this Section were made. Between 1934 and 1935 Psychology separated from Education. In these early years round table conferences and invited addresses by nationally recognized figures were part of the annual programs. Some of these famous personalities and their topics were Professor J. F. Dashiell on *The Concept of Personality*; Dr. John Jenkins on *Psychotechnology*; Dr. S. H. Britt on *The Future of Social Psychology*; and Professor Clark Hull on *Motivation*.

During the 1940's the problem of the need for applied psychologists became a major topic for Section meetings. In 1948 the Section became affiliated with the American Psychological Association (APA). The restrictions placed on APA membership as opposed to the open membership principle of VAS led to the establishment of the Virginia Psychological Association (VPA) in 1956. Until 1968 the VAS Psychology Section and the VPA held joint meetings. These joint meetings were discontinued in 1968 as

the VPA gradually became a professional association concerned with the training of practitioners and with legislation concerning the regulation of the practice. With the separation of the VPA from the VAS Psychology Section, the meetings of the last decade have returned to the typical academic-scientific focus of the early years.

During the 4 decades prior to 1976, over 700 papers were presented. Twenty-six papers by undergraduates, graduate students, and professors from seven colleges and universities presented at the last meeting of the Academy reflect the academic-scientific emphasis of the last decade in the Psychology Section's programs.

On Friday, May 12, 1978, the Psychology Section will schedule a symposium entitled *Psychology in Virginia*. This will be chaired by Professor Emeritus William M. Hinton of Washington and Lee University, a former Section Chairman and VAS President. The symposium scheduled for the 1978 meeting will include Professor Frank Finger of U.Va. who will speak on *The History of the VAS Psychology Section*. Professor Frank Murray, R-MWC, will discuss today's undergraduate programs; Professor Paul Woods, Hollins, will discuss master's degree programs; and Professor James Deese, U.Va., will discuss doctoral programs. Much of their presentations will be based on a survey of the activities of the state's four-year colleges and universities currently being conducted by the Section's officers. Robert Tipton, President of VPA, and Richard Abidin, Chairman of the Virginia Board of Psychologists Examiners will present views of current scenes from their organizations. A perspective on psychology in Virginia will be presented by Professor B. von Haller Gilmer, the first person ever to be awarded a PH.D. in psychology by a Virginia institution.

Frank Murray  
 Randolph-Macon Women's College

### WANTED

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# ANNOUNCEMENTS

## ENVIRONMENTAL SCIENCE SECTION TO AWARD PRIZES

The Environmental Science Section of the Virginia Academy of Science shall award two prizes for the best papers presented at the 1978 annual meetings of the VAS and VJAS.

The *Roscoe Hughes Graduate Paper Award* shall go to the best research paper presented by a graduate student. The award carries a certificate and a cash prize of \$40. The letters of intent, including the title of paper, author's name and address should reach Gilmore Trafford, Office of the Director, NASA, Wallops Flight Center, Wallops Station, Virginia 23337 before February 1, 1978. Three copies of the manuscript, limited to 10 double-spaced typed pages (about 3000 words) or equivalent, must reach him before March 1, 1978. Brevity and sufficient precise detail shall be important considerations in the selection. The final selection of the winner and the presentation of the award will be made at the 56th annual meeting of the Virginia Academy of Science to be held on May 10-12, 1978 at VPI and SU, Blacksburg.

The *Roscoe Hughes Junior Paper Award* shall go to the best paper in any field of the environmental sciences to be presented at the 37th annual meeting of the VJAS to be held in Blacksburg on May 9-11, 1978. The award, carrying a certificate and \$10 cash prize, shall be presented at the VJAS Awards session on May 11, 1978.

## SREB INVITES APPLICATIONS FOR SMALL GRANTS

The Southern Regional Education Board (SREB) operates a small grants program which enables faculty and Ph.D. students in natural sciences in institutions in 14 southern states (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Texas, Virginia, and West Virginia) to obtain support for expenses incurred while traveling to use uncommon equipment and facilities not available on their own campuses. Support is given primarily for activities which enhance the learning process or have a direct relationship to the course of study. The grants cover expenses which result from the use of off-campus facilities and equipment, in particular living and travel expenses and charges assessed for use. Numerous facilities which may be used are listed in the *Catalog of Uncommon Facilities in Southern Universities*, a publication of SREB.

To apply for a grant, typically in the \$150-\$500 range, two steps must be taken: First, contact the appropriate official at the institution holding or operating the unusual equipment or facility to explain your desired use and to arrange possible dates for a visit, anytime during September 1977 through November 1978. Second, apply by letter to SREB for financial support, giving the name and location of the facility to be visited, the educational purposes of the visit, and estimated costs for transportation, living expenses, and use of the facility or equipment. Include an endorsement from a school official (department chairman, faculty advisor, etc.) and mail the letter to Dr. Edwin C. Godbold, Director of Administration, Southern Regional Education Board, 130 Sixth Street, N.W., Atlanta, GA. 30313.

## SUMMER FELLOWSHIPS AT MOUNTAIN LAKE

Four fellowships of \$200 each are available for graduate study during the summer of 1978 at the Mountain Lake Biological Station. In addition to Drs. William Odum and Elizabeth Conant of UVa, six visiting faculty will participate in instruction. They are Drs. Donald Farrar (Iowa State), Harry Jackson (Bridge-

water College), Janis Antonovics (Duke), Carl Keener (Penn. State), Clifford Johnson (U. Fla.), and Charles Handley, Jr. (U.S. National Museum). Enquiries about the study program and applications for fellowships may be addressed to the Director, Mountain Lake Biological Station, University of Virginia, Charlottesville, VA 22903.

## SEAPORT SYSTEM MANAGEMENT PROGRAM AT ODU

As an urban university with a commitment to serve the Tidewater area, Old Dominion University is starting an interschool cross-disciplinary program, consisting of seminars (open to the public) and courses (for credit) in *Seaport System Management*. Cosponsored by the National Science Foundation, the program begins in January 1978. For details, write to Dr. Harold G. Marshall, Director, Seaport System Management Program, Old Dominion University, Norfolk, VA 23508.

## DRUG EXPERT AS PSYCHIATRY CHAIRMAN AT MCV

Dr. Robert O. Friedel, a nationally recognized expert on drugs used in treating senility and psychiatric problems related to aging, has joined the Medical College of Virginia as Chairman of the Psychiatry Department. Dr. Friedel received all his professional education and training at Duke University and spent two years at the National Institute of Mental Health, Bethesda, Md. as staff associate in biochemistry prior to becoming Director of Clinical Services at the University of Washington School of Medicine. Widely published in journals and texts, Dr. Friedel is a member of the American College of Neuropsychopharmacology, American Psychiatric Association, American Society for Pharmacology and Experimental Therapeutics, American Society for Neurochemistry, American Federation for Clinical Research, and the American Association for the Advancement of Science.

## ENGINEERING AND PSYCHOLOGY SECTIONS PLAN SYMPOSIA

Two sections have made plans for special symposia as part of their section's activities at the next annual meeting of the Virginia Academy of Science to be held at VPI and SU on May 11-12, 1978.

The engineering section has picked the theme *Water Quality Engineering—What Have We Learned from PL 92-500?* The panelists will be drawn from the academic, industrial, and governmental sectors.

The psychology section's symposium has the title *Psychology in Virginia*. Chaired by Professor Emeritus William M. Hinton of Washington and Lee University, the symposium will include the following topics: history of the psychology section (Frank Finger, U.Va.), today's undergraduate programs (Frank Murray, R-MWC), Master's degree programs (Paul Woods, Hollins College), doctoral programs (James Deese, U.Va.), Virginia Psychiatric Association Perspectives (Robert Tipton, VPA), Virginia Board of Psychologists Examiners Perspective (Richard Abiden, VBPE), and a Perspective on Psychology in Virginia (B. von Haller Gilmer).



# PAPERS TO APPEAR IN THE WINTER 1977 ISSUE

## ARTICLES

The Genus *Hieracium* L. (Cichorieae-Asteraceae) in Virginia. *Miles F. Johnson*, Virginia Commonwealth University

Effect of Light Intensity on Photoreactions in Mesophyl and Bundle Sheath Chloroplasts Isolated from Corn Leaves (*Zea Mays* L.). *Shaw S. Lee*, Virginia State College

Passage of a Weak Vortex Sheet Through an Oblique Shock. *Lu Ting*, New York University

## NOTES

Introduction of *Notropis Cerasinus* (Cope) into the Appomattox River Drainage. *Tom M. Abbott*, *Kenneth L. Dickson* and *Wayne A. Potter*, Virginia Polytechnic Institute and State University

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Articles (other than abstracts, correspondence and comments, and news and notes) should be sent to the Editor, Dr. Kuldip P. Chopra, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA. 23508. Manuscripts dealing with science and society, history of science and technology, correspondence, and news and notes should be addressed to the Associate Editor, Dr. Michael N. Bishara, Engineering Division, Southwest Community College, Richlands, VA. 24641. Short notes (not exceeding eight double-spaced typed pages, 2500 words or equivalent including illustrations) may be sent to the Editor or one of the members of the Editorial Board. Proofs, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

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# VIRGINIA JOURNAL OF SCIENCE

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VOL. 28, NO. 4

WINTER 1977





# THE VIRGINIA JOURNAL OF SCIENCE

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## GUEST EDITORIALS



William E. Lavery  
*President, VAS*

We at Virginia Tech look forward to being host for the 56th Annual Meeting of the Virginia Academy of Science (VAS) and the 37th Annual Meeting of the Virginia Junior Academy of Science (VJAS), to be held jointly on our campus, May 9-12, 1978.

At Virginia Tech we take a great deal of interest and pride in the meetings and other activities of these two outstanding organizations. We were last host for the meetings in 1971, and we welcome their return to our campus.

We are proud of our participation in the VAS. Virginia Tech, along with twenty-two other Virginia colleges and universities, has been a continuing, sustaining member of the Academy, and we claim more individual memberships than any other institution. The Virginia Journal of Science was started on our campus under the stewardship of Dr. Boyd Harshbarger, the founder and editor-in-chief. Our University has provided seven presidents of the Academy; a dozen of our faculty have won the top research prize, and one-fifth of the Fellows are from Virginia Tech. Three of our faculty have served as editors of the Virginia Journal of Science, and three as directors of the VJAS. Over a third of the some 400 papers presented at the annual meeting each year are given by our faculty and graduate students. A dozen or so of our faculty are now serving as officers or chair persons of Council, sections and standing committees.

It is with this kind of commitment to the VAS and VJAS that we look forward to being host to the 500 scientists and 300 top high school science students who will attend the 1978 meetings. Participants will be assured of a warm welcome to our campus and of our maximum effort to make the meetings successful.



Ralph A. Lowry  
*President, VPI & SU*

As president of the Academy this year, I have on occasions found it necessary to pause and reflect on the purpose and goals of the Academy. Since its founding, the Academy has developed or sponsored many special programs and activities which continue today. These activities often reflect the interests and dedicated work of past Academy leaders, playing a major role in the growth and visibility of the Academy, benefiting not only the members but promoting, to quote the Constitution, "the civic, agricultural, academic, industrial and economic welfare of the people of Virginia." While we are justly proud of our many accomplishments, I propose not to dwell on them but rather to seek the underlying source of strength and leadership which brought them about.

The Academy has a special meaning and significance for each of us. How and why did we become members? Our senior colleagues were members and encouraged us to join their sections, attend the annual meeting, present papers, and have our graduate students present papers. In other words, we started as a member of a section. For many of us, the section's activities were our only involvement in the Academy for the first few years. It is only when one is elected as a section representative to Council or appointed to a committee that he or she becomes aware of the broader aspects of the Academy's program. As was intended by the Constitution, the sections are the foundation of the Academy. It is in the sections that the majority of Academy members from our educational institutions, industries, and state agencies in Virginia come together for cooperation and fellowship, to present and discuss their scientific work, and to exchange information on the scientific and academic programs in their respective disciplines at the various organizations and institutions. The future leaders of the Academy will come from the ranks of the sections; we depend heavily on the sections to recruit new members.

To forget the importance of the role of the sections is to invite serious problems. Thus, as we approach the time for the Academy's 1978 Annual Meeting, the major activity for most sections, we should keep in mind that for a section to be strong and effective good attendance and participation at the Annual Meeting is essential. Much planning has gone into section programs and the Local Arrangements Committee at VPI & SU has done an outstanding job of planning and preparing for the Meeting, and excellent facilities are being provided. Section officers have planned outstanding programs, but it will be a truly successful year for the Academy only if every member who possibly can attends the Annual Meeting and participates in his section's program. Bring a colleague with you and join us in Blacksburg on May 11-12, 1978.

# The Genus *Hieracium* L. (Cichorieae—Asteraceae) in Virginia

Miles F. Johnson

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(Received March 28, 1977 Revised August 10, 1977)



Miles F. Johnson, associate professor of biology and curator of herbarium. Received B.S. (1958), U. of Wisconsin at River Falls; M.S. (1962), U. of Wisconsin at Madison; and Ph.D. (1968), U. of Minnesota, Minneapolis. Research interests: flora of Virginia, especially Asteraceae, and plant taxonomy.

cluding agamospermy, contributing to the formation of microspecies and various ambiguous taxa. The following key delineates the 10 species known in Virginia.

## Key to Species

- A. Scapose, or nearly so, bearing a well-developed basal rosette .....B.
- B. Heads red-orange; rare in Virginia .....1. *H. aurantiacum*.
- BB. Heads yellow; more widespread in Virginia .C.
- C. Heads borne singly.....2. *H. pilosella*.
- CC. Heads borne in racemose, corymbiform or paniculate clusters .....D.
- D. Leaves conspicuously red or purple veined .....3. *H. venosum*.
- DD. Leaves not red or purple veined .....E.
- E. Plants stoloniferous.....F.
- F. Leaves glaucous and glabrous or nearly so on upper surface .....4. *H. floribundum*.
- FF. Leaves not glaucous, but hairy on both surfaces .....5. *H. pratense*.
- EE. Plants not stoloniferous .....G.
- G. Heads large, involucre 8-13 mm high, corymbiform .....6. *H. traillii*.
- GG. Heads smaller, 6-7.5 mm high, cymose .....7. *H. florentinum*.
- AA. Stems leafy, without a well-developed basal rosette.....H.
- H. Leaves conspicuously pale green and glaucous beneath, gradually reduced upward, the heads borne on flexuous peduncles .....8. *H. paniculatum*.
- HH. Leaves not pale green beneath, abruptly reduced upward, the heads borne on stout peduncles.....I.
- I. Achenes distinctly narrowed toward the apex.....9. *H. gronovii*.
- II. Achenes truncate, not tapered toward the apex .....10. *H. scabrum*.

1. *Hieracium aurantiacum* L. King Devil; Devil's Paint Brush; Orange Hawkweed.

Stoloniferous, abundantly hairy-glandular scapose perennial with basal spatulate to oblong leaves and bearing compact corymbiform clusters of bright red-orange heads is known from a single collection from Virginia: Grayson Co., Cabin Ridge, July 27, 1954

This paper continues the series begun in 1971 (Johnson 1971 *et seq.*) which treats the floristic taxonomy of certain genera in the Asteraceae in Virginia. This study is based upon personal study of about 550 herbarium specimens and field work in Virginia. I gratefully acknowledge the assistance given by curators and/or directors of the herbaria as previously reported (Johnson 1975) who allowed me access to the collections.

Dots on the maps indicate exact locations; squares indicate a collection from that county without specific location data. Stars indicate collections cited in the literature although the specimens have not been seen personally during this study.

Nomenclature follows Fernald (1950), Gleason and Cronquist (1963) and Radford et al. (1968). A survey of the Virginia Cichorieae with a generic key and treatment of all genera except *Hieracium* and *Prenanthes* are found in a previous paper (Nessler 1976).

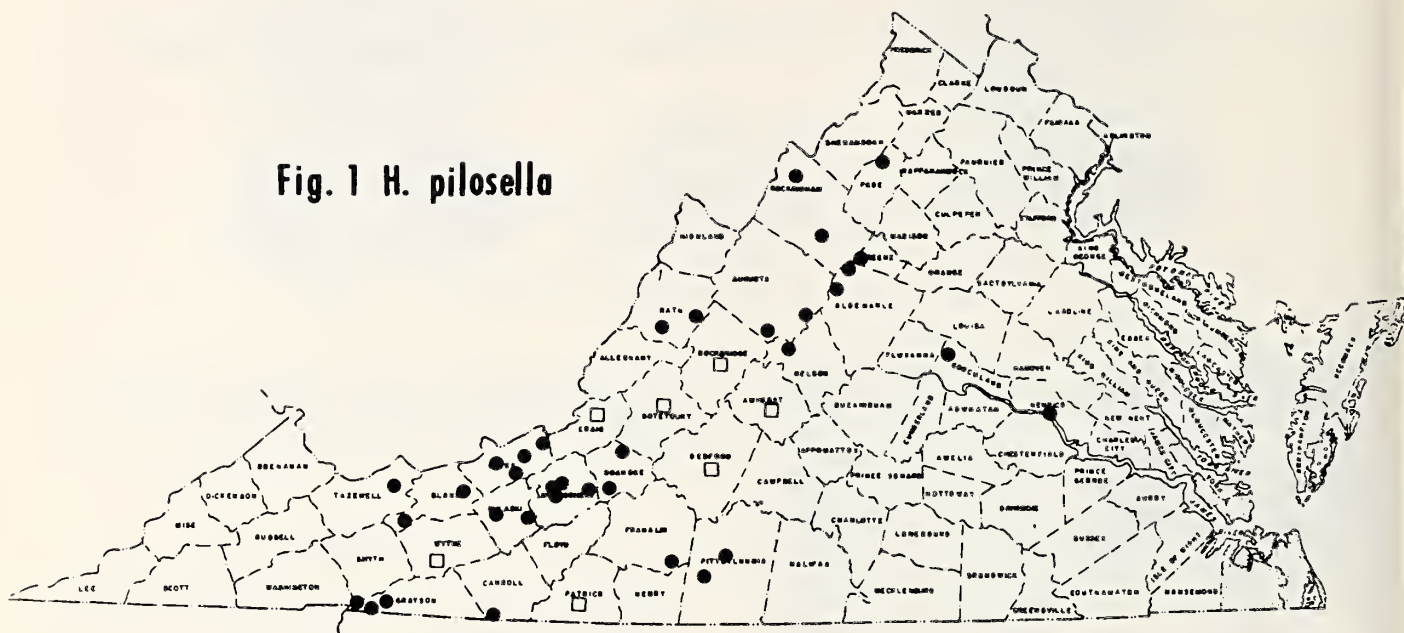
## Taxonomic Treatment

*Hieracium* L. Hawkweed.

Perennial herbs with milky sap. Stems scapose or leafy, simple or branched. Leaves basal or cauline, entire to dentate, petiolate to sessile. Inflorescence of a single head or heads in racemose, paniculate or corymbose clusters. Involucral bracts imbricated, glandular and variously pubescent. Corollas bright yellow or red-orange. Achenes columnar or fusiform, not beaked. Pappus of capillary bristles in a single series.

*Hieracium* is a large genus (1,000 species, cf. Willis, 1973) of great taxonomic complexity with interspecific hybridization, polyploidy and apomixis, in-



Fig. 1 *H. pilosella*

(fl), Shields 168-23 (VPI).  $2n = 27, 30, 36, 45, 54, 63$  (Moore 1973); apomictic (Christoff 1942).

It is an aggressive, troublesome weed throughout its range which is generally north and west of Virginia.

2. *Hieracium pilosella*. L. Mouse-Ear Hawkweed.

Stoloniferous and scapose, to 3 dm tall when flowering, becoming taller in fruit, rarely bearing a leafy stem; leaves basal, oblanceolate, (3.0) 4-9.2 (11) cm long, 0.6-1.8 cm wide, long setose on upper surface, long setose and stellate on lower surface, leaves of stolons similar but slightly reduced; heads borne singly (rarely in pairs) on tomentose and black stipitate glandular scapes; involucre 7-10 mm high, stellate and bearing black hispid and gland-tipped hairs,

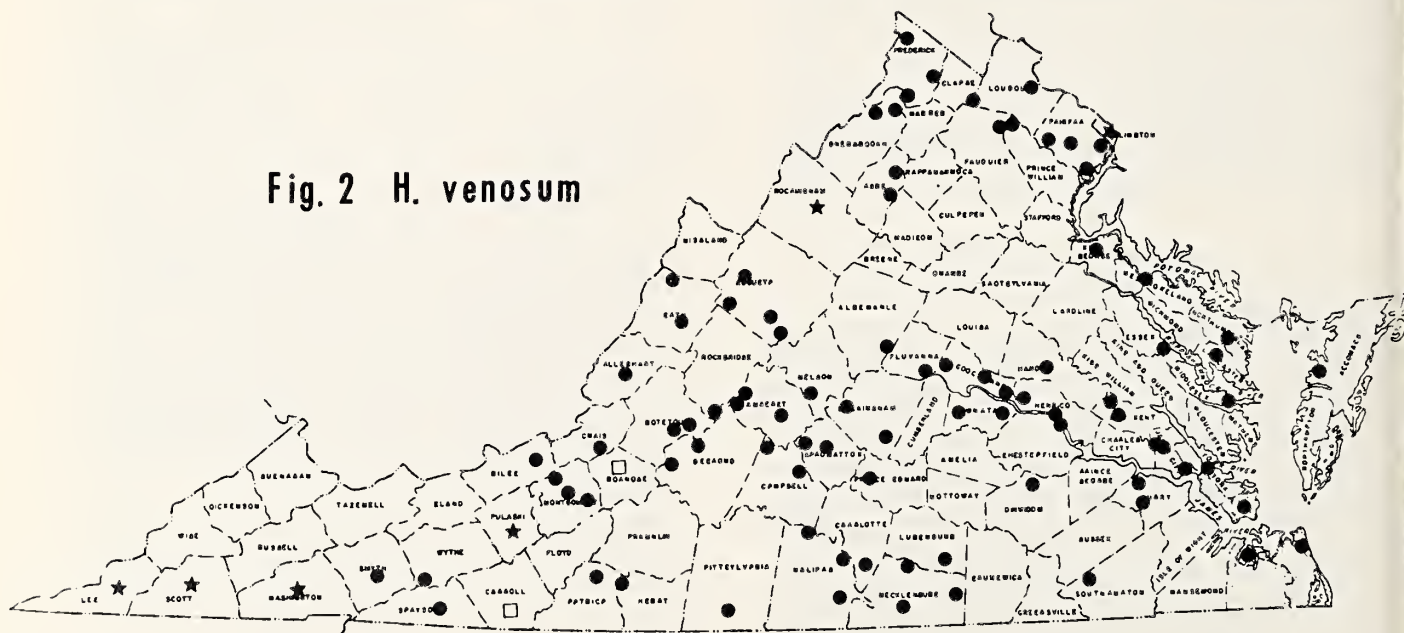
reflexed in fruit; achenes ca. 2 mm long, columnar; pappus ca. 4 mm long, off white.  $2n = 18, 36, 45, 54$  (Moore 1973).

It is a troublesome weed and frequent west of the Blue Ridge (Figure 1) along roadsides, in open fields, in pastures, on hillsides, on shale and limestone, becoming rare to the east. It is in flower and fruit from early May to late July.

The single scapose inflorescence and stolons distinguish *H. pilosella*.

3. *Hieracium venosum* L. Rattlesnake-Weed.

Scapes (1.7) 2.5-6.5 dm tall, at times bearing 1 or more well-developed cauline leaves; leaves usually basal, elliptic to ovate, (2.4) 5-15 (18) cm long, (1.7) 1.9-4.6 (5) cm wide, densely setose along margin and

Fig. 2 *H. venosum*

toward the base to subglabrous, the veins usually red-purple; heads corymbiform on diverging pedicels; involucre 7-8 (9) mm high, glabrous to stipitate glandular; achenes ca. 3 mm high, columnar; pappus ca. 4.5 mm long.

*H. venosum* is common throughout (Figure 2) in dry hardwoods, along roadsides, in sand, shale and limestone. Carr (1965) reports the species from Lee County, Massey (1961) from Arlington, Pulaski, Rockingham, and Scott, and Jervis (1969) from Washington County. It is in flower from early April through June and again from late July through September, and in fruit from mid-April through mid-September.

A plant of suspected hybrid origin between *H. venosum* and *H. gronovii* was seen from Nansemond County (Duke Q-3445, UNC) during this study. Those with *H. paniculatum* are reported from Dickinson and Rockingham Counties (Uttal and Mitchell 1972).

*H. venosum* var. *nudicaule* (Michaux) Fernald, attributed to northern Virginia (Fernald 1950) is not recognized as distinct (cf. Uttal and Mitchell 1972).

The red-purple venation is a distinctive feature of *H. venosum*.

4. *Hieracium floribundum* Wimm. & Grab. King-Devil.

Stoloniferous, scapes ca. 3 dm tall; leaves basal, lanceolate to oblong, 3.5-15 cm long, 2.5 cm wide, marginally long setose with glaucous and glabrous upper surfaces; heads corymbiform, borne on rather stout, hispid, glandular pedicels; involucre ca. 1 cm high, hispid, glandular; achenes ca. 2 mm long, columnar; pappus ca. 5 mm long,  $2n = 27$  (Moore 1973).

This European native, ranging generally north of Virginia, is known from three collections: Allegheny Co.: common weed on shale at Covington, May 28, 1937 (fr), Massey s.n. (VPI); Augusta Co.: Reddish Knob, North River Refuge, George Washington Na-

tional Forest, June 16, 1936 (fr) Mosby 1-3 (VPI); Bath Co.: shale on barren by dump between Millboro and Millboro Springs, Aug. 6, 1972 (fr), Stevens, Harvill, & Carr 5625 (Longwood).

The basal rosette of glaucous and glabrous leaves distinguishes this taxon from similar species.

5. *Hieracium pratense* Tausch. King Devil; Field Hawkweed.

Stoloniferous and scapose, (1.8) 2.3-0.9 dm tall, rarely bearing 1-3 reduced leaves; leaves basal, elliptic to oblanceolate, (7) 7.5-21 (23) cm long, 1.1-3.4 (3.7) cm wide, long pilose on both surfaces; heads corymbiform, borne on a pilose, black stipitate-glandular scape; involucre 6-7 mm high, bearing long setose, stellate and black stipitate hairs; achenes ca. 2 mm long; pappus 4-5 mm long, off white.  $2n = 18, 27, 36, 45$  (Moore 1973).

A pernicious weed which may form dense mats in disturbed areas, it is common west of the Blue Ridge on roadsides, in fields, woods and clearings, becoming less common on the Piedmont and Coastal Plain (Figure 3). It is reported from Henrico, Scott and Shenandoah Counties (Massey 1961) and from Washington County (Jervis 1969). It is in flower from mid-April through July and in fruit through mid-September.

The basal rosette of leaves pilose over both surfaces distinguishes this species.

6. *Hieracium traillii* Greene. Devil's Paint Brush.

*H. greenii* Porter & Britton, *H. x marianum* Willd., sensu Radford, et al., 1968.

Scapose, 3.3-6.7 (8.3) dm tall, branched above, densely pilose below to densely stellate and stipitate glandular toward the inflorescences; leaves basal, oblanceolate to elliptic, (6) 8.5-15 (19) cm long, 0.9-3.6 (4.1) cm wide, long pilose over the lower surface, at times only over the veins, sparingly pilose to glabrous above, not purple veined; heads corymbiform, borne on densely stellate and conspicuously yellow stipitate glandular peduncles; involucre 8-13 mm high, bear-

Fig. 3 *H. pratense*

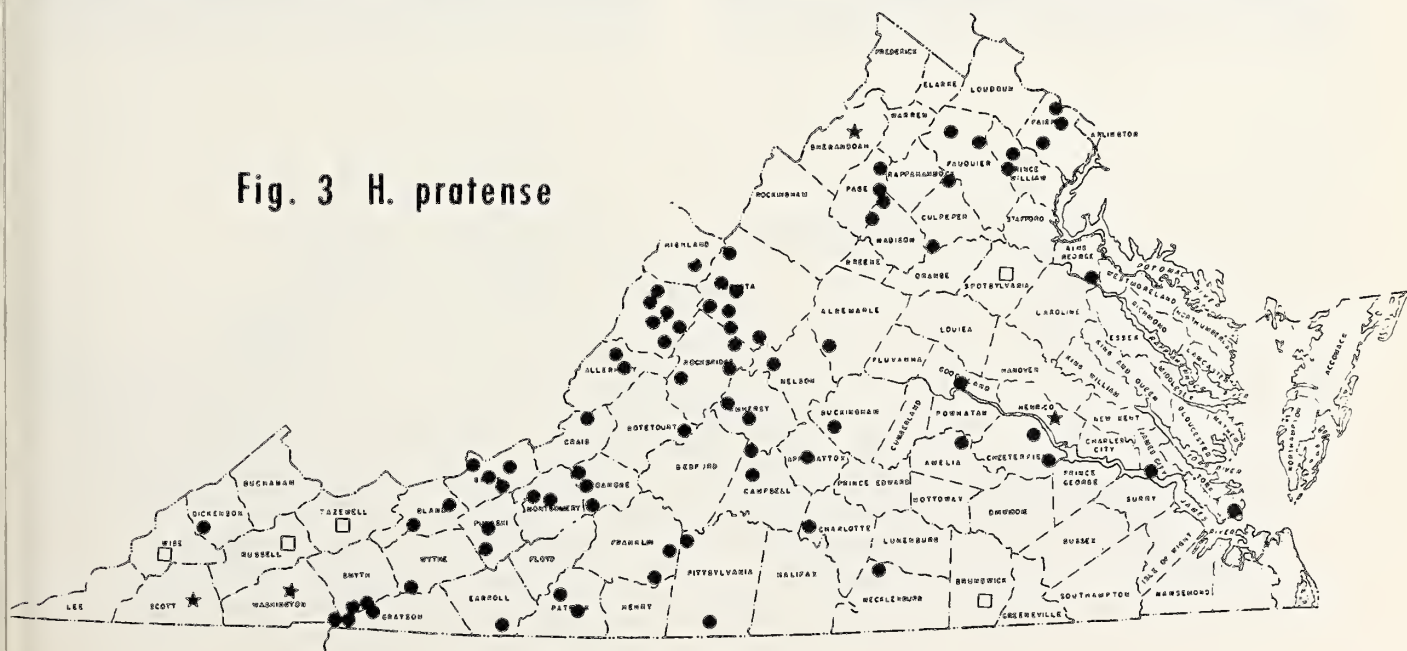






Fig. 7 *H. gronovii*

scattered hairs over lower veins; heads borne in open corymbiform panicles on long, flexuous, sparingly glandular peduncles; involucre (4) 6–8 mm high, sparingly stipitate glandular; achenes ca. 2 mm high, columnar; pappus 4–5 mm long, pale tan.

*H. paniculatum* is relatively common west of the Blue Ridge (Figure 6) on wooded banks, on roadsides, in woods and meadows. It is in flower from (mid-June) late July through September and fruiting into early October.

*H. paniculatum* is not readily misidentified as the combination of pale green lower leaf surfaces and flexuous peduncles serve well to distinguish this taxon.

Suspected hybrids are formed with the following species in Virginia:

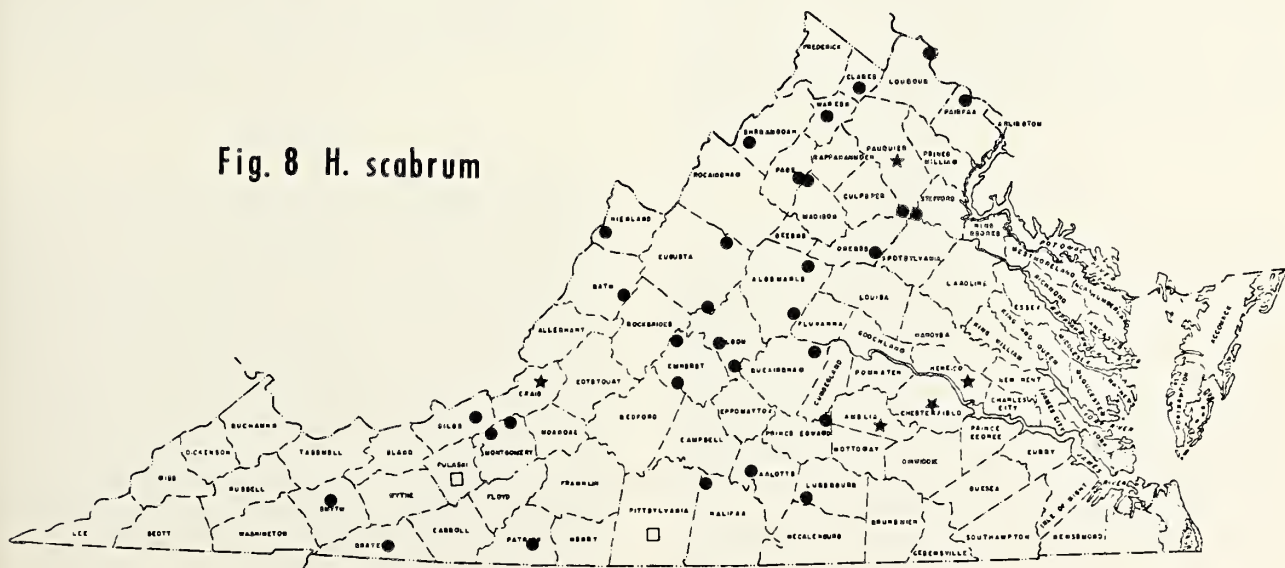
*H. scabrum*—specimens bearing glaucous lower leaf surfaces and glandular peduncles were seen from Fairfax Co. (Bradley and Kelley 7096, VCU) and Virginia Beach (Leonard and Killip 275, US); *H. veno-*

*sum*—reported from Dickinson and Rockingham Counties (Uttal and Mitchell 1972); *H. gronovii*—these plants have been named *H. x marianum* Willd. (Uttal & Mitchell 1962; Radford et al. 1968) and are reported from Amelia, Craig, Page and Westmoreland Counties (Uttal and Mitchell 1972).

#### 9. *Hieracium gronovii* L.

Stems (2.0) 3–11 (14.7) dm tall, densely and conspicuously long pilose basally; basal rosette leaves oblanceolate to ovate, 4–15 (18) cm long, (1.7) 2.2–4.2 (5.6) cm wide, pilose and at times stellate, rapidly reduced and bract-like and sessile-clasping upward; heads borne on puberulent and stipitate-glandular peduncles in narrow cylindrical panicles; involucre (6) 8–9 mm high, generally glabrous or basally glandular; achenes fusiform, 3–4 (4.5) mm long; pappus 3–4 mm high, pale brown.  $2n = 18$  (Moore 1973).

This species is most abundant on the Coastal Plain and becomes relatively uncommon west of the Blue Ridge (Figure 7), in sand, dry woods and roadsides.

Fig. 8 *H. scabrum*



It is in flower from late June/mid-July to early October and in fruit from mid-July through mid-October.

The upper naked stem and glabrous involucre bracts in combination with the fusiform achenes distinguish *H. gronovii* from similar species.

*H. gronovii* is suspected of forming hybrids with *H. venosum* and *H. paniculatum* (see these taxa in this paper).

10. *Hieracium scabrum* Michaux. Rough Hawkweed.

Stems 5–11 dm tall, densely pubescent basally and in the inflorescence; basal leaves lanceolate and petiolate, (4.5) 6.3–19 cm long, (1.8) 2.4–4.5 (5.2) cm wide, generally long setose; heads borne on densely stipitate glandular pedicels in an elongate, narrow panicle; involucre 7–8.5 mm high, pubescence hispid, gland-tipped and stellate; achenes 2.0–2.5 mm high, columnar; pappus 4–7 mm high, tawny.

*H. scabrum* occurs along roadsides, in woods and fields from the Fall Line west (Figure 8). It is reported from Pittsylvania County (Hathaway and Ramsey 1973) and from Amelia, Craig, Fauquier, Greene and Henrico Counties (Massey 1961). It is in flower from mid-August through September and in fruit through mid-October.

The large basal leaves becoming reduced upwards and the heads borne in narrow panicles on densely and conspicuously stipitate glandular peduncles distinguishes *H. scabrum*.

Hybrids with *H. venosum* (cf. Radford *et al.* 1968) and *H. paniculatum* (see this paper) are known.

*Hieracium flagellare* Willd., a coarse, stoloniferous plant, is reported from the State (Fernald 1950), but no specimens were seen during this study.

#### Literature Cited

- Carr, L. G. K. 1965. Floristic elements in southwestern Virginia, a phytogeographical consideration. *Castanea* 30:105–144.
- Christoff, M. 1942. Die Genetische Grundlage der Apomiktischen Fortpflanzung bei *Hieracium aurantiacum* L. Z.f. Verebgsl. 80:103–105.
- Fernald, M. L. 1950. Gray's manual of botany, 8th Ed. American Book Co., New York.
- Gleason, H. A., and A. Cronquist. 1963. Manual of the vascular plants of Northeastern United States and adjacent Canada. D. Van Nostrand Co, Inc., Princeton.
- Hathaway, W. T., and G. W. Ramsey. 1973. The flora of Pittsylvania County, Virginia. *Castanea* 38:38–79.
- Jervis, R. A. 1969. Additions to the flora of Washington County and southwestern Virginia. *Castanea* 34:99–121.
- Johnson, M. F. 1971a. The genus *Liatris* in Virginia. *Castanea* 36:137–147.
- . 1971b. The genera *Carphephorus*, *Mikania* and *Kuhnia* (Eupatorieae-Asteraceae) in Virginia. Va. Jour. Sci. 22 (2):38–41.
- . 1972. Eupatorieae (Asteraceae) in Virginia: *Eupatoriadelphus*, *Ageratina*, *Fleischmannia* and *Conoclinium*. Va. Jour. Sci. 23:48–55.
- . 1974a. Eupatorieae (Asteraceae) in Virginia: *Eupatorium* L. *Castanea* 39:205–228.
- . 1974b. Cynareae (Asteraceae) in Virginia: *Cirsium*, *Carduus*, *Onopordum*. Va. Jour. Sci. 25:152–160.
- . 1975. Cynareae (Asteraceae) in Virginia: *Arctium*, *Centaurea*, *Cnicus*. *Castanea* 40:63–73.
- , and J. Joosten. 1977. Vernonieae (Asteraceae) in Virginia: *Vernonia* and *Elephantopus*. *Castanea*: in press.
- Massey, A. B. 1961. Virginia Flora. Va. Ag. Sta. Tech. Bull. 155. Blacksburg.
- Moore, R. J., Editor. 1973. Index to plant chromosome numbers 1967–1971. Oostoeck's Uitgeversmaatschappij B. V. Utrecht, Netherlands.
- Mulligan, G. A. 1961. Chromosome numbers of Canadian weeds III. Can. Jour. Bot. 39:1057–1066.
- Nessler, Craig L. 1976. A systematic survey of the tribe Cichorieae in Virginia. *Castanea* 41:226–248.
- Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the Vascular flora of the Carolinas. The University of North Carolina Press, Chapel Hill.
- Uttal, L. J., and R. S. Mitchell. 1972. Amendments to the flora of Virginia, II. *Castanea* 27:96–119.
- Willis, J. C. 1973. A dictionary of the flowering plants and ferns, 8th Ed. Cambridge University Press.

# Effects of Light Intensity on Photoreactions with Chloroplasts Types from Corn Leaves

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**Abstract**—Mesophyll and bundle sheath chloroplasts have been isolated and purified from maize leaves by differential grinding and discontinuous sucrose gradient centrifugation. Both mesophyll and bundle sheath chloroplasts showed activity in the reduction of DPIP, ferricyanide and  $\text{NADP}^+$ , and in cyclic and noncyclic photophosphorylation. Maize chloroplasts isolated in the medium omitting vacuum infiltration show lower Hill reaction activity. Rates of Hill reactions with either ferricyanide or DPIP as electron acceptor are two to three times higher in the presence of methylamine as an uncoupler in spinach or maize mesophyll chloroplasts. However, in bundle sheath chloroplasts, methylamine stimulates ferricyanide reduction to a lesser extent and practically has no effect on DPIP reduction. Light intensity versus activity curves indicated that corn mesophyll chloroplasts, like spinach chloroplasts, show light saturation at 10,000 to 30,000 lux for the three most common Hill reactions and noncyclic photophosphorylation and at 100,000 lux for PMS-mediated cyclic photophosphorylation. In sharp contrast, the rates of reduction of DPIP, ferricyanide and  $\text{NADP}^+$  saturated at 80,000 to 100,000 lux, and the rates of both cyclic and noncyclic photophosphorylation still do not saturate at 150,000 lux in bundle sheath chloroplasts.

## Introduction

One of the most distinct physiological differences between  $\text{C}_3$  and  $\text{C}_4$  plants is their response of photosynthesis rate to increasing light intensity. The photosynthesis rate in  $\text{C}_4$  plants continues to increase with increasing light intensity up to full sunlight while the photosynthesis rate in  $\text{C}_3$  plants reaches saturation at 2,000 to 3,000 footcandles (Black et al. 1969). Since anatomical data indicate the presence of distinct mesophyll and bundle sheath chloroplasts in leaves of  $\text{C}_4$  species and only mesophyll chloroplasts in leaves of  $\text{C}_3$  species (Haberlandt 1914), and since isolated chloroplasts of some  $\text{C}_3$  species are capable of carrying out complete photosynthesis (Jenson and Bassham 1966), studies of the effects of light intensity on photochemical and carboxylation reactions by iso-

lated chloroplasts from these two groups of plants may yield insight into the mechanisms underlying these physiological and anatomical differences.

Studies of the effect of light intensity on photochemical and carboxylation reactions in  $\text{C}_3$  species indicated that chloroplasts isolated from  $\text{C}_3$  plants showed light saturation at 1,000 to 3,000 footcandles for the reduction of NADP (Turner et al. 1962) and TCIP (Jagendorf and Avron 1958), NADP coupled photophosphorylation (Turner et al. 1962), vitamin K-mediated photophosphorylation (Arnon 1961), and  $\text{CO}_2$  fixation (Turner et al. 1962). Only PMS-mediated cyclic photophosphorylation continued to increase with increasing light intensity (Black et al. 1969; Turner et al. 1962; Chen et al. 1969). In a blue-green alga, *Anabaena variabilis*, both  $\text{FMN}_3$ -mediated and  $\text{DPIP}_2$ -mediated photophosphorylation saturated at 1,000 to 2,000 footcandles, PMS-mediated cyclic photophosphorylation at 8,000 to 10,000 footcandles, and ferricyanide reduction did not reach saturation at 15,000 footcandles (Susor et al. 1964). In *R. rubrum* photoreduction of NAD by the bacterial chromatophores showed light saturation at 1,000 footcandles (Vernon and Ash 1959). Previous reports on the effect of light intensity on Hill reaction, cyclic and noncyclic photophosphorylation by isolated chloroplasts of  $\text{C}_4$  plants are limited (Chen et al. 1969; Anderson et al. 1972b). This investigation describes the effects of light intensities on the photoreduction of DPIP, ferricyanide, and  $\text{NADP}^+$ ; PMS-mediated cyclic photophosphorylation and noncyclic photophosphorylation with mesophyll and bundle sheath chloroplasts from a  $\text{C}_4$  plant, corn, and mesophyll chloroplasts from a  $\text{C}_3$  plant, spinach.

## Materials and Methods

**Isolation of bundle sheath chloroplasts:** Corn seedlings *Zea mays* (L.) were grown in a temperature-controlled greenhouse for two to three weeks in soil. The daytime temperature was set at 72°F and the nighttime at 60°F, and a photoperiod of 16 hours of light was maintained by a bank of Gro-Lux fluorescent lamps. The procedure used for the isolation of maize bundle sheath chloroplasts was a modified method of Woo et al. (1970) as outlined in Figure 1. Twenty grams of the corn leaves were cut transversely into 2 to 3 mm long pieces, vacuum infiltrated for 5 minutes, and blended at high speed in a prechilled Waring blender (Waring Products Corporation,



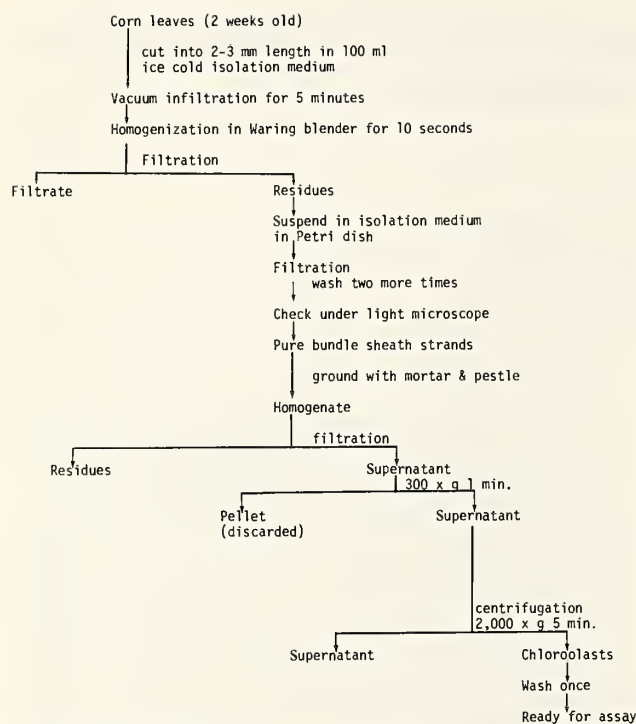


FIG. 1—Flow chart of technique for isolating bundle sheath chloroplasts from *Zea mays* (L.).

Model No. PB-5) for 10 to 30 seconds in 100 ml of ice-cold isolation medium containing 0.4 M sucrose, 0.01 M NaCl, 0.05 M tricine-NaOH, 600 mg polyethylene glycol 4,000 and 10 mM dithiotreitol (DTT pH 8.0). The length of blending time varied according to the age of the plants (10 seconds for 2-week-old plants and 30 seconds for 4-week-old plants). The blending essentially removed all mesophyll cells and very few bundle sheath cells. The homogenate was filtered through two layers of Miracloth. The residue on the Miracloth was resuspended in 40 ml of the isolation medium without DTT and polyethylene glycol, and the suspension was filtered through 2 layers of Miracloth again to wash out the contaminated mesophyll chloroplasts. Washing was repeated two to three more times until the purity of bundle sheath strands was assured under light microscope. The pure bundle sheath strands, essentially free from mesophyll cells and/or chloroplasts, were then quickly ground in 40 ml of ice-cold isolation medium without DTT and polyethylene glycol with a pre-chilled mortar and pestle. The homogenate was filtered through Miracloth and the filtrate centrifuged for 1 minute at  $300 \times g$  to remove cell debris. Bundle sheath chloroplasts were collected by centrifugation for 5 minutes at  $2,000 \times g$ . The pellet was washed once and resuspended in 4.0 ml of the isolation medium. Using a procedure including the vacuum infiltration step greatly improved the Hill activity of bundle sheath chloroplasts as measured by the reduction of DPIP or ferricyanide.

**Isolation of mesophyll chloroplasts:** The isolation procedures are outlined in Figure 2. Greenhouse-grown corn leaves from 20 plants of 2 to 3 weeks old

were cut into 1 to 2 mm length in 100 ml ice-cold isolation medium and vacuum infiltrated for 5 minutes with laboratory vacuum line. This was followed by homogenization in a Sorvall Omnimixer at 50 percent line voltage as described by Woo et al. (1970). The homogenate was then filtered through two layers of Miracloth, and the filtrate was centrifuged at  $300 \times g$  for 1 minute. The pellet was discarded. The supernatant was then centrifuged at  $2,000 \times g$  for 5 minutes. The pellet thus obtained was washed once in the same isolation medium without DTT and polyethylene glycol. The chloroplasts were further purified according to the method of Baldry et al. (1968) in 10 ml of medium containing 0.4 M sucrose, 0.05 M tricine-NaOH, and 0.01 M NaCl (PH. 8.0). A pale green pellet was obtained from the bottom of the tube. Mesophyll chloroplasts at the interface were removed, diluted with 20 ml of isolation medium and recentrifuged at  $2,000 \times g$  for 5 minutes. The pellets were resuspended in 2.5 ml of the isolation medium.

**Isolation of spinach chloroplasts:** Spinach was purchased locally, and chloroplasts were prepared according to the method of Gibbs and Calo (1959) in isolation medium containing 0.4 M sucrose, 0.01 M NaCl and 0.05 M tricine-NaOH pH 8.0

**Assay of photochemical reactions:** Photoreduction of Hill oxidants were measured spectro-photometrically with a Beckman Model B spectrophotometer at the following wavelengths: 420 nm for ferricyanide, 600 nm for 2, 6-dichlorophenol indophenol (DPIP) and 340 nm for  $\text{NADP}^+$ . All experiments were carried out in triplicate and at room temperature. The reaction mixture in a final volume of 3 ml contained chloroplasts equivalent to 10 to 20  $\mu\text{g}$  chlorophyll and the following chemicals in

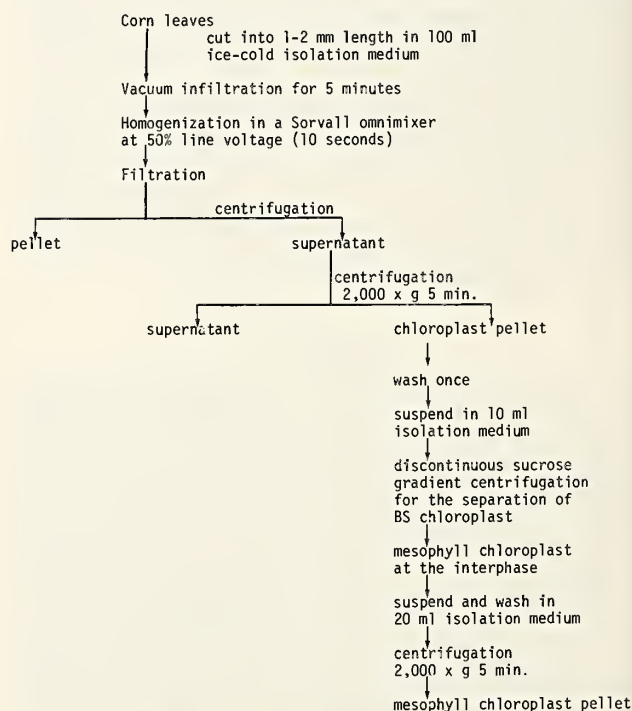


FIG. 2—Flow chart of technique for isolating mesophyll chloroplasts from *Zea mays* (L.).

umoles: ferricyanide, 1; tricine-NaOH, 70;  $MgCl_2$ , 10, pH 7.8 for the reduction of ferricyanide; DPIP, 0.06; tricine-NaOH, 70, pH 7.8 for the reduction of DPIP;  $NADP^+$ , 0.6; tricine-NaOH, 40; NaCl, 70, pH 7.8,  $MgCl_2$ , 10, pH 7.8 and a saturated amount of spinach ferredoxin 0.2 mg (San Pietro and Lang 1958) for the reduction of  $NADP^+$ . The method of measurement of cyclic photophosphorylation activity was essentially the same as that described by Jagendorf and Avron (1958). In ferricyanide coupled photophosphorylation 0.5 umole of potassium ferricyanide was used instead of PMS. The reaction mixtures were illuminated for 30 seconds for DPIP, 2 minutes for ferricyanide and  $NADP^+$  reduction, 10 minutes for photophosphorylation with two 500-watt photoflood lamps shining on a mirror immersed under water in a 10-gallon aquarium tank. Light intensity was varied by adjusting the distance between the light source and the cuvettes containing the reaction mixtures. Light intensity was measured with a super pilot Cds precision exposure meter.

**Chlorophyll determination:** Chlorophyll was determined according to the method of Arnon (1949).

## Results

### Hill Reaction and Photophosphorylation Activity

Isolated chloroplasts from either spinach ( $C_3$ ) or corn ( $C_4$ ) are capable of reducing DPIP, ferricyanide and  $NADP^+$  without adding exogenous substances such as albumin and carbowax 4000. Table 1 shows Hill reaction activity of spinach mesophyll, maize mesophyll and bundle sheath chloroplasts, and mixed maize chloroplasts. The rates of DPIP and ferricyanide reduction in corn bundle sheath chloroplasts are lower than those in spinach mesophyll chloroplasts, but are comparable to the activity of corn mesophyll chloroplasts. In contrast to a previous report (Woo et al. 1970), these results are in agreement with those of Anderson et al. (1972a), Mayne et al. (1971), and Bazzaz and Govindjee (1973) that photosystem II is functioning in isolated mesophyll and bundle sheath chloroplasts of  $C_4$  plants. The rate of DPIP and ferricyanide reduction shows about a 2:1 ratio between mesophyll and bundle sheath chloroplasts when the chloroplasts are prepared without an infiltration step. This observation is consistent with the report of

TABLE I  
Hill Reaction Activities of Chloroplasts Isolated from Spinach Mesophyll Cells, Maize Mesophyll and Bundle Sheath Cells

Preparation	Reduction	Ferricyanide Reduction umoles/mg chlorophyll/hr	$NADP^+$ Reduction
Spinach chloroplasts	350	450	80
Corn mesophyll chloroplasts (+ infiltration step)	74 $\pm$ 27 (3)	192 $\pm$ 27 (4)	20
Corn mesophyll chloroplasts (- infiltration step)	56 $\pm$ 20 (5)	112 $\pm$ 49 (3)	12
Corn bundle sheath chloroplasts (+ infiltration step)	88 $\pm$ 2 (3)	130 $\pm$ 8 (3)	30
Corn bundle sheath chloroplasts (- infiltration step)	33 $\pm$ 4 (4)	61 (2)	22
Mixed corn chloroplasts*	130	140	17

\*Mixed corn chloroplasts = Mesophyll chloroplasts + Bundle Sheath chloroplasts  
Intensity of illumination = 40,000 lux. Methylamine, Pi and ADP were not added in the reaction mixture.

TABLE 2  
Photophosphorylation in Chloroplasts Isolated from Spinach Mesophyll Cells, Corn Mesophyll and Bundle Sheath Cells

Preparation	Cyclic Photophosphorylation umoles/mg chlorophyll/hr	Non-cyclic Photophosphorylation umoles/mg chlorophyll/hr
Spinach mesophyll chloroplasts	1300	225
Corn mesophyll chloroplasts	500 (520)	300 (96)
Corn bundle sheath chloroplasts	400 (537)	200 (14)
Corn mixed chloroplasts	450	165

\*Experimental condition and light intensity are identical to those of Table 1. cyclic photophosphorylation with PMS, non-cyclic photophosphorylation with Ferricyanide. The figures in parentheses are obtained from Anderson et al.

Mayne et al. (1971). Incorporating the infiltration step in the isolation procedure greatly improved the activity of the chloroplast as measured by the reduction of DPIP and ferricyanide.  $NADP^+$  reduction in bundle sheath chloroplasts is much lower than those of spinach chloroplasts; however, it is comparable to corn mesophyll chloroplasts. This strongly suggests that photosystem I and photosystem II are not only active but also linked in all chloroplasts isolated from the three cell types. Spinach chloroplasts, corn mesophyll chloroplasts, bundle sheath chloroplasts, and mixed maize chloroplasts are active in both PMS-catalyzed cyclic photophosphorylation and ferricyanide coupled noncyclic photophosphorylation although the noncyclic photophosphorylation is always lower in all preparations (Table 2). The rates of cyclic photophosphorylation in corn mesophyll chloroplasts are comparable to those of Anderson et al. (1971a) and Polya and Osmond (1972), while the rates of bundle sheath chloroplasts are lower than their values. However, the rate of noncyclic photophosphorylation is much higher than their values of 11 to 16 umoles/mg chlorophyll/hr for bundle sheath chloroplasts. The rates of noncyclic photophosphorylation are quite similar among the three chloroplast types. Hill reaction activities of the three chloroplast preparations in the presence and absence of the uncoupler methylamine are shown in Table 3. The rate of DPIP and ferricyanide reduction in spinach and corn mesophyll chloroplasts in the presence of methylamine are two to three times higher than those in the absence of the uncoupler. However, in maize bundle sheath chloroplasts methylamine is only effective in stimulating ferricyanide reduction but ineffective in stimulating DCIP reduction. These results are slightly different from previous reports (Anderson et al. 1971a, 1971b) in that methylamine was unable to increase the rate of either TCIP or ferricyanide reduction in maize and sorghum bundle sheath chloroplasts.

**Effect of Light Intensity on Photochemical Reactions**—Previous studies of photochemical reactions in isolated spinach chloroplasts ( $C_3$  plant) clearly indicated that only the rate of PMS-mediated cyclic photophosphorylation continued to increase with increasing light intensity up to the full sunlight (Turner et al. 1962; Jagendorf and Avron 1958). The rates of TCIP-reduction,  $NADP^+$  reduction, and noncyclic photophosphorylation (either ferricyanide or  $NADP^+$ ) saturated at 20,000 to 30,000 lux (Turner et



TABLE 3  
Hill-Reaction Activities of Chloroplasts Isolated  
from Corn & Spinach Leaves

Chloroplasts	DPIP Reduction ( $\mu\text{moles/mg chl/hr}$ )		Ferricyanide Reduction ( $\mu\text{moles/mg chl/hr}$ )	
	-MA	+MA	-MA	+MA
Spinach	145	300	349	683
Corn mesophyll	57	155	187 $\pm$ 23	520 $\pm$ 30
Corn bundle Sheath	90 $\pm$ 1	95 $\pm$ 7	131 $\pm$ 8	229 $\pm$ 5

Light intensity = 20,000/ux

M.A. = methylamine 40  $\mu\text{moles}$

Reactions were carried out at room temperature

al. 1962; Jagendorf and Avron 1958). Figure 3 shows the ferricyanide reduction saturates at 20,000 to 40,000. This is in sharp contrast to the ferricyanide reduction of algal particles which did not saturate even at full sunlight intensity (Susor et al. 1964). Figure 4 shows light intensity curves of Hill reaction, cyclic and noncyclic photophosphorylation by maize mesophyll chloroplasts. The patterns are essentially similar to those of spinach chloroplasts. In sharp contrast, the rates of reduction of DPIP, ferricyanide, and  $\text{NADP}^+$ , PMS-catalyzed photophosphorylation, and ferricyanide coupled photophosphorylation in maize bundle sheath chloroplasts reach saturation at much higher light intensity than the corresponding reactions in mesophyll chloroplasts isolated either from spinach or corn leaves. Figure 5 shows the rate of photochemical reaction versus light intensity in corn bundle sheath chloroplasts. The rates of the three most common Hill reactions (DPIP, ferricyanide, and  $\text{NADP}^+$ ) reach a plateau at 80,000 to 100,000 lux as shown in Figures 5A and 5C. Figures 5B and 5D show that PMS-catalyzed cyclic photo-

phosphorylation and ferricyanide coupled photophosphorylation do not saturate even at 150,000 lux. Anderson et al. (1971a, 1972b) briefly reported higher light saturation curves for maize bundle sheath Hill reaction activity to mesophyll chloroplast activity. The so-called "low light intensity effect" as reported by Turner et al. (1962) also occurs between 250 and 500 footcandles in all PMS-catalyzed cyclic photophosphorylation regardless of sources of chloroplasts used.

## Discussion

The problem of a functional electron transport system in mesophyll and bundle sheath chloroplasts of  $\text{C}_4$  plants has been studied in several laboratories throughout the world since Woo et al. (1970) first reported that agranal bundle sheath chloroplasts of sorghum and corn were deficient in photosystem II activity. In the same year, Mayne et al. (1971) reported the presence of a complete electron transport pathway from oxygen evolution to the reduction of  $\text{NADP}^+$  in both mesophyll and bundle sheath cells of *D. sanguinalis* (L.) Smillie et al. (1972) also showed that bundle sheath chloroplasts from corn or sorghum possessed the potential for electron flow between photosystem I and photosystem II. These results were further confirmed by Bazzaz et al. (1973). They showed that the entire electron transport chain was present in both types of chloroplasts based on the use of methyl viologen as an electron acceptor and the presence of an antagonistic effect of red and infrared light on cytochrome changes. The results of many laboratories including ours show that corn mesophyll chloroplasts are similar to spinach chloroplasts in photosynthetic electron transport system (Mayne et al. 1971a, 1971b; Bazzaz and Govindjee 1973; Anderson et al. 1971c; Boardman 1971; Lee et al. 1970). However, mesophyll and bundle sheath chloroplasts are different in view of ultrastructural, physiological, and biochemical characteristics: presence of rudimentary grana in bundle sheath chloro-

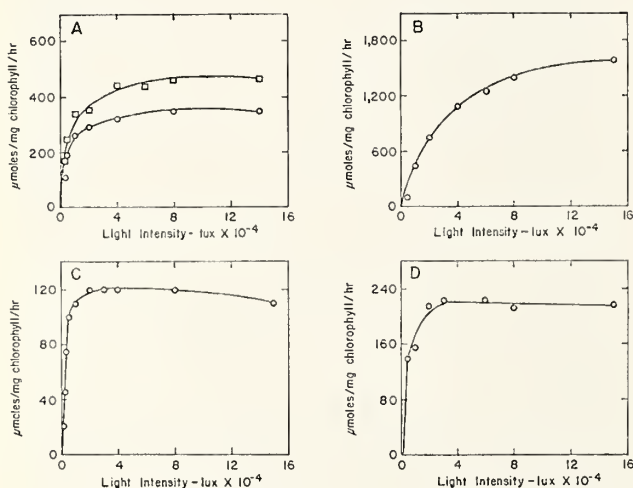


FIG. 3—The effect of light intensity on photochemical reactions by spinach chloroplasts. A,  $\square$ — $\square$ , ferricyanide reduction;  $\circ$ — $\circ$ , DPIP reduction. B, PMS-catalyzed cyclic photophosphorylation. C,  $\text{NADP}^+$  Photoreduction. D, ferricyanide coupled noncyclic photophosphorylation. Experimental procedures and conditions are described in the text.

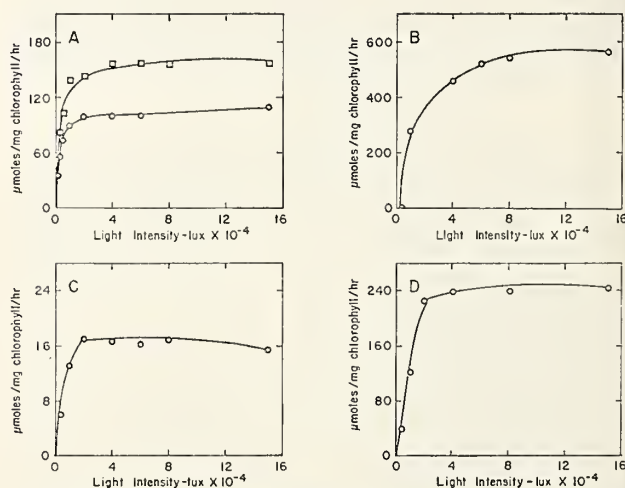


FIG. 4—Effect of light intensity on photochemical reactions by maize mesophyll chloroplasts. Symbols and experimental conditions are identical to those of Figure 3.

plants and fully developed grana in mesophyll chloroplasts; more starch in bundle sheath than mesophyll chloroplasts (Black and Mollenhauer 1971); higher RUDP carboxylase and low PEP carboxylase in bundle sheath than mesophyll chloroplasts (Edwards et al. 1970); stimulation of TCIP and ferricyanide reduction by methylamine in mesophyll chloroplasts and lack of such stimulation in bundle sheath chloroplasts (Anderson et al. 1971a, 1971b); the inability of bundle sheath chloroplasts to photoreduce NADP<sup>+</sup> (Woo et al. 1970; Smillie et al. 1972); linkage of PS I and II in mesophyll chloroplasts but no linkage in bundle sheath chloroplasts (Bishop et al. 1972); high photophosphorylation (cyclic and noncyclic) in mesophyll chloroplasts but low noncyclic photophosphorylation in bundle sheath chloroplasts (Anderson et al. 1971a; Polya and Osmond 1972); smaller photosynthetic unit in bundle sheath chloroplasts (250–280) than mesophyll chloroplasts (400–500) (Anderson et al. 1971b, 1971c); three-banded spectra in mesophyll and only a small emission in the 680 to 690 nm region (Anderson et al. 1971c); larger chlorophyll a/b ratio in bundle sheath chloroplasts (5.8) than that of mesophyll chloroplasts (3.1) (Anderson et al. 1971b, 1971c); higher rate of Hill reaction in mesophyll than bundle sheath chloroplasts in the absence of methylamine uncoupler (Anderson et al. 1971b); higher light saturation of Hill activity in the bundle sheath chloroplasts than in the mesophyll chloroplasts (Anderson et al. 1972b). In contrast to previous reports, we have found that both maize mesophyll and bundle sheath chloroplasts were capable of reducing NADP<sup>+</sup>. This suggests that photosystem I and photosystem II are not only active but also linked in both chloroplasts types.

Stimulation of ferricyanide reduction and lack of stimulation of DPIP reduction in bundle sheath chloroplasts may suggest that DPIP accepts an electron before a photophosphorylation site and ferricyanide accepts an electron after a noncyclic photophosphorylation site. The sites of ferricyanide and DPIP reduction in mesophyll chloroplasts are probably identical since methylamine greatly stimulates both reactions in spinach and corn mesophyll chloroplasts (Table 3).

The question of level of photosystem II activity in two chloroplast types is still an open dispute. Woo et al. (1970) first reported that bundle sheath chloroplasts isolated from corn or sorghum were deficient in photosystem II activity. Anderson et al. (1971c) showed that bundle sheath chloroplasts with sorghum and maize have only 11 to 19 percent as much photosystem II as mesophyll chloroplasts. Mayne et al. (1971a) with crabgrass and Bazzaz and Govindjee (1973) with maize reported that bundle-sheath chloroplasts have 50 percent as much PS II activity as mesophyll chloroplasts. However, Ku et al. (1974), Anderson et al. (1971a, 1972a) and Mayne et al. (1974) concluded that mesophyll chloroplasts have three to four fold more photosystem II activity than bundle sheath chloroplasts of NADP-malic enzyme C<sub>4</sub> plants. Chloroplasts isolated from some C<sub>3</sub>, C<sub>4</sub>, and CAM plants such as green onions, tomato leaves, pineapple, philodendron etc., also show low or no activity of Hill reaction (Lee 1975) as natural inhib-

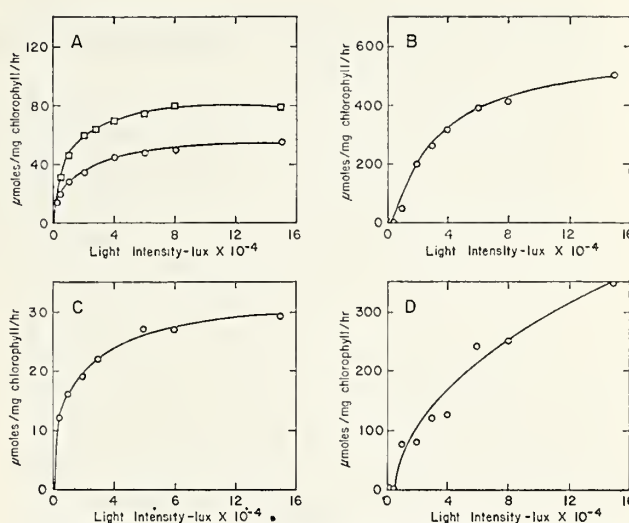


FIG. 5—Effect of light intensity on photochemical reactions by maize bundle sheath chloroplasts. Symbols and experimental procedures are identical to Figure 3.

itors such as tannin, phenolic compounds or low acidity in leaf sap has been shown to irreversibly inactivate chloroplasts before chloroplasts were released into the isolation medium (Clendenning 1957). The addition of polyethylene glycol 4000 or vacuum infiltration of leaves with dilute tricine buffer before homogenization greatly increased Hill activity of isolated chloroplasts. Consequently, the level of photosystem II activity obtained from assays of the Hill reaction are not as reliable as those obtained from techniques of fluorescence spectra, and delayed light emission (Mayne et al. 1974). Elkin (1973) also has thoroughly investigated photosystem II activity in bundle sheath chloroplasts of a number of species and indicated that they had at least some photosystem II activity. But the results of electron transport studies in bundle sheath chloroplasts do conflict, and further research is needed to clarify the differences.

#### Acknowledgements

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#### Literature Cited

- Anderson, K. S., Bain, J. M., Bishop, D. G., and R. M. Smillie. 1972a. Photosystem II activity in agranal bundle sheath chloroplasts from *Zea mays*. *Plant physiol.* **49**:461–466.
- Anderson, J. M., Boardman, N. K., and D. Spencer. 1971a. Photophosphorylation by intact bundle sheath chloroplasts from maize. *Biochem. Biophys. Acta* **245**:253–258.
- Anderson, J. M., Woo, K. C., and N. K. Boardman. 1971b. Photochemical systems in mesophyll and bundle sheath chloroplasts of C<sub>4</sub> plants. *Biochem. Biophys. Acta* **245**:398–408.
- Anderson, J. M., Woo, K. C., and N. K. Boardman. 1971c. Photochemical properties of mesophyll and bundle sheath chloro-



- plasts from  $C_4$  plants. In: Photosynthesis and photorespiration pp. 353-360. Hatch, M. D., Osmond, C. B., Slatyer, R. O., ed., Wiley-Interscience.
- Anderson, J. M., Woo, K. C., and N. K. Boardman. 1972b. Deficiency of photosystem II in agranal bundle sheath chloroplasts of *Sorghum bicolor* and *Zea mays*. In: II International Congress on Photosynthesis Research. Eds. G. Forti, M. Avron, and A. Melandri. Dr. W. Junk N. V. Publishers, The Hague. Vol. I, pp. 611-619.
- Arnon, D. I. 1949. Copper enzymes in isolated chloroplasts. Polyphenol oxidase in *Beta vulgaris*. Plant physiol. **24**:1-15.
- Arnon, D. I. 1961. Role of vitamin K and other quinones in photosynthesis. Fed. proc. **20**:1012-1022.
- Baldry, C. W., Coombs, J., and D. Gross. 1968. Isolation and separation of chloroplasts from sugar cane. Z. pflanzenphysiol. Bd. **60**:578-81.
- Bazzaz, M. B., and Govindjee. 1973. Photochemical properties of mesophyll and bundle sheath chloroplasts from maize. Plant physiol. **52**:257-262.
- Bishop, D. G., Anderson, K. S. and R. M. Smillie. 1972. Incomplete membrane bound photosynthetic electron transfer pathway in agranal chloroplasts. Biochem. Biophys. Res. Commun. **42**:74-81.
- Black, C. C., Chen, T. M., and R. H. Brown. 1969. Biochemical basis for plant competition. Weed Science **14**:338-344.
- Black, C. C., and H. H. Mollenhauer. 1971. Structure and distribution of chloroplasts and other organelles in leaves with various rates of photosynthesis. Plant Physiol. **47**:15-23.
- Boardman, N. K. 1971. The photochemical systems in  $C_3$  and  $C_4$  plants. In: photosynthesis and photorespiration pp. 209-222, Hatch, M. D., Osmond, C. B., Slatyer, R. O., ed., Wiley-Interscience.
- Chen, T. M., Brown, R. H., and C. C. Black. 1969. Photosynthetic activity of chloroplasts isolated from Bermuda grass (*C. dactyloides* L.), a species with a high photosynthetic capacity. Plant physiol. **44**:649-654.
- Clendenning, K. A. 1957. Biochemistry of chloroplasts in relation to the Hill reaction. Ann. Rev. Plant Physiol. **8**:137-152.
- Edwards, G. E., Lee, S. S., Chen, T. M. and C. C. Black. 1970. Carboxylation reactions and photosynthesis of carbon compounds in isolated mesophyll and bundle sheath cells of *Digitaria sanguinalis* (L.) Scop. Biochem. Biophys. Res. Commun., **39**:389-395.
- Elkin, L. 1973. Bundle sheath and mesophyll chloroplasts of  $C_4$  plants: an in situ comparison of their room temperature fluorescence. Ph.D. Thesis, University of California at Berkeley, 565 pp.
- Gibbs, M. and N. Calo. 1959. Factors affecting light induced fixation of carbon dioxide by isolated spinach chloroplasts. Plant physiol. **34**:318-323.
- Haberlandt, G. 1914. Physiological plant anatomy. MacMillan and Co. London. pp. 777.
- Jagendorf, A. T., and M. Avron. 1958. Cofactors and rates of photosynthetic phosphorylation by spinach chloroplasts. J. Biol. Chem. **231**:277-290.
- Jenson, R. G., and J. A. Bassham. 1966. Photosynthesis by isolated chloroplasts. Proc. Nat. Acad. Sci. U.S. **56**:1095-1101.
- Ku, S. B., Gutierrez, M., Kanai, R., and G. E. Edwards. 1974. Photosynthesis in mesophyll protoplasts and bundle sheath cells of various types of  $C_4$  plants. II Chlorophyll and Hill reaction studies. Z. Pflanzenphysiol. Bd. **72**:320-337 (1974).
- Lee, S. S. 1975. Effect of light intensity on photoreaction in mesophyll and bundle sheath chloroplasts (*Z. mays* L.) Plant Physiol. **56**:S46.
- Lee, S. S., Travis, J., and C. C. Black. 1970. Characterization of Ferredoxin from nutsedge *Cyperus rotundus* L. and other species with a high photosynthetic capacity. Arch. Biochem. Biophys. **141**:676-689.
- Mayne, B. C., Dee, A. M., and G. E. Edwards. 1974. Photosynthesis in mesophyll protoplasts and bundle sheath cells of various types of  $C_4$  plants. III fluorescence Emission Spectra, Delayed Light Emission, and  $P_{700}$  content. Z. Pflanzenphysiol. Bd. **74**:S275-291.
- Mayne, B. C., Edwards, G. E., and C. C. Black, Jr. 1971a. Spectral, physical, and electron transport activities in photosynthetic apparatus of mesophyll cells and bundle sheath cells of *Digitaria sanguinalis* (L.) Scop. Plant physiol. **49**:600-605.
- Mayne, B. C., Edwards, G. E., and C. C. Black, Jr. 1971b. Light reactions in  $C_4$  photosynthesis. In: Photosynthesis and photorespiration pp. 361-371. Hatch, M. D., Osmond, C. B., Slatyer, R. O., ed., Wiley-Interscience.
- Polya, G. M., and C. B. Osmond. 1972. Photophosphorylation by mesophyll and bundle sheath chloroplasts of  $C_4$  plants. Plant Physiol. **49**:267-269.
- San Pietro, A. and H. M. Lang. 1958. Photosynthetic pyridine nucleotide reductase I, partial purification and properties of the enzyme from spinach. J. Biol. Chem. **231**:211-229.
- Smillie, R. M., Anderson, K. S., Tobin, N. F., Entsch, B., and D. G. Bishop. 1972. Nicotinamide adenine dinucleotide phosphate photoreduction from water by agranal chloroplasts isolated from bundle sheath cells of maize. Plant physiol. **49**:471-475.
- Susor, W. A., Duane, W. C., and D. W. Krogmann. 1964. Studies on photosynthesis using cell-free preparations of blue-green algae. Record Chem. Prog. **25**:197-208.
- Turner, J. F., Black, C. C., and M. Gibbs. 1962. Studies on photosynthetic process I. The effect of light intensity on triphosphopyridine nucleotide reduction, adenosine triphosphate formation and carbon dioxide assimilation in spinach chloroplasts. J. Biol. Chem. **237**:577-579.
- Vernon, L. P., and O. K. Ash. 1959. The photoreduction of pyridine nucleotides by illuminated chromatophores of *Rhodospirillum rubrum* in the presence of succinate. J. Biol. Chem. **234**:1878-1882.
- Woo, K. C., Anderson, J. M., Boardman, N. K., Downton, W. J. S., Osmond, C. B., and S. W. Thorne. 1970. Deficient photosystem II in agranal bundle sheath chloroplasts of  $C_4$  plants. Proc. Nat. Acad. Sci. USA **67**:18-25.

# Passage of a Weak Vortex Sheet through an Oblique Shock

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**Abstract**—The two-dimensional problem of the passage of a free vortex sheet of weak strength through an oblique shock wave of finite strength is investigated. Conditions are established which define the changes of the strength and shape of the vortex sheet after its passage through the shock wave in terms of the shock strength and the angle between the shock wave and the vortex sheet.

## Introduction

In a unsteady flow or a steady supersonic flow, shock waves can be present. They may be created by an explosion, by converging compression waves, by impulsive motion of a body, or by the motion of a body at supersonic speed. The shock front is an idealization of shock layer with thickness much smaller than its radii of curvature. Although the changes across the shock layer are caused by the viscosity and conductivity of the fluid, these changes can be obtained directly from the conservation laws of mass, momentum and energy in the flow fields ahead of and behind the shock wave where viscosity and conductivity can be neglected. Across the shock wave, the tangential velocity components are continuous. The discontinuity in pressure is balanced by that of the normal component of velocity. The kinetic energy is converted to thermal energy with an increment in entropy.

In a flow field discontinuities can also occur across material surfaces across which the normal velocity components of the fluids must be continuous and equal to the velocity of the surface. Consequently, the pressure must be continuous, while the tangential velocity components and the densities can be discontinuous. Of course the material surface of discontinuities is again a mathematical idealization of a thin diffusion layer. If there is a discontinuity in density across the material surface, it is known as an interface separating two fluids. If the discontinuity is in tangential velocity components, the surface is known as a vortex sheet, for example, the vortex sheet separating the wake region behind a body and the main stream and the vortex sheet behind the trailing edge of a wing. The vortex sheets may roll up to form vortex filaments or vortex rings.

The reflection and diffraction of a weak shock or an acoustic wave by an interface with discontinuities of finite strengths have been investigated by many physicists and mathematicians. The interaction of a strong shock wave with a vortex sheet of weak strength is studied in the present article.

The interaction of a shock wave with turbulent eddies in the flow field has been investigated in recent years as a source for noise generations, as shock diffraction problems and as problems in wind tunnel design. The turbulent eddies were modeled by vorticity distributions, vortex surfaces or filaments.

The solution to the two-dimensional problem of the passage of a free point vortex of weak strength through a normal shock wave was obtained by Fourier transform technique (Ribner 1959) by the method developed for shock diffraction problems and as the limiting case of a vortex sheet (Ting 1974). The three-dimensional problem of the passage of a free vortex surface through a normal shock wave was treated by Ting (1975).

This paper will present the general case of the passage of a vortex sheet through an oblique shock wave. The vortex sheet ahead of the shock wave intersects the shock at an arbitrary angle  $\alpha_1$  which is not related to the shock angle  $\beta_1$ . To demonstrate the main features of the analysis and the results only the two-dimensional problem is treated here. The extension to the three-dimensional case is rather straightforward.

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## Statement of the Problem

For the undisturbed flowfield, i.e., without the vortex sheet, the flow is steady when the coordinate axes are fixed on the shock front. The y-axis represents the shock front, and the positive x-axis points toward the region behind the shock. The pressure, density and velocity components are denoted by  $P_k, \rho_k, U_k$  and  $V_k$  respectively with  $k = 1$  for the region ahead of the shock ( $x < 0$ ) and  $k = 2$  for that behind the shock ( $x > 0$ ). We denote  $C_k$  and  $M_k$  as the speed of sound

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and the Mach number of the normal component of the velocity, i.e.,

$$C_k^2 = \gamma P_k / \rho_k \text{ and } M_k = U_k / C_k \quad (1)$$

We consider the fluid to be an ideal gas, and  $\gamma$  is the ratio of specific heats. The quantities behind the shock are related to those ahead of the shock by the well-known shock conditions (Liepman and Roshko 1957). In particular, we note,

$$V_1 = V_2 = U_1 \cot \beta_1 = U_2 \cot \beta_2 = V \quad (2)$$

$$\frac{U_2}{U_1} = \frac{\rho_1}{\rho_2} = \frac{(\gamma - 1)M_1^2 + 2}{(\gamma + 1)M_1^2} = \Lambda(M_1) \quad (3)$$

and

$$P_2/P_1 = 1 + 2\gamma(M_1^2 - 1)/(\gamma + 1) \quad (4)$$

with  $M_1 > 1$  and  $M_2 < 1$ .

Here  $\beta_1$  and  $\beta_2$  indicate the angles between the shock front and the velocity ahead and that behind the shock. Equation (4) shows that  $M_1$  is the parameter defining the shock strength.

In the  $x$ - $y$  plane, the vortex sheet is represented by a line segment AB of length  $L_1$  which lies ahead of the shock front from  $t < 0$  as shown in Figure 1a. The increment of the tangential velocity from the lower surface to the upper surface of the vortex sheet is denoted by  $-\epsilon\sigma_1(s_1)$  where  $s_1$  is the arc length measured from the leading edge A with  $0 \leq s_1 \leq L_1$ ;  $\epsilon$  is defined as the ratio of the maximum absolute value of the tangential velocity increment and  $U_1$ , and  $\epsilon\sigma_1$  is known as the *linear intensity* of the vortex sheet because the total vorticity of the element  $ds_1$  of the sheet, which is equal to the circulation around the contour of the element  $ds_1$ , is  $\epsilon\sigma_1 ds_1$ . For a vortex sheet of weak strength,  $\epsilon$  is much less than unity and will be employed as the small parameter for the formulation of the linearized analysis.

Under the linearized theory, the vortex sheet is moving with the undisturbed stream in order to avoid

a pressure difference across the sheet. This is valid since we are interested only in the time interval when the vortex sheet is near the shock front. The time interval is of the order of  $L_1 \sin \alpha_1 / U_1$  so that the displacement induced by the vortex sheet will be of the order  $\epsilon L_1$  and hence ignorable.

For  $t < 0$ , the position of the vortex segment AB is given by the parametric equations

$$x_1(s_1, t) = U_1 t - s_1 \sin \alpha_1 \quad (5)$$

$$y_1(s_1, t) = V_1 t - s_1 \cos \alpha_1 \quad (6)$$

where  $\alpha_1$  is the angle between the vortex sheet and the shock. We locate the origin at the point where the leading edge A passes through the shock at the instant  $t = 0$ .

We denote the disturbance pressure, density and velocity components due to the vortex sheet by  $\epsilon p_k$ ,  $\epsilon \rho_k'$ ,  $\epsilon u_k$  and  $\epsilon v_k$  respectively. Since the flow ahead of the shock is supersonic, the flow field in  $x < 0$  is unaffected by the presence of the shock and remains isentropic. For a coordinate system moving with the undisturbed stream ahead of the shock, the vortex sheet is stationary and the flow field ahead of the shock is steady. The velocity which is induced by the vortex sheet with strength  $\epsilon\sigma_1$  is of the order  $\epsilon$ . From the Bernoulli equation, the disturbance pressure is proportional to the square of the velocity and is of the order of  $\epsilon^2$ . Since the flow is isentropic, the disturbance density is also of the order  $\epsilon^2$ . Therefore, under the linearized theory we have

$$p_1 \equiv 0 \quad \text{and} \quad \rho_1' \equiv 0 \quad (7)$$

Since the shock front is disturbed, the flow behind the shock ( $x > 0$ ) is rotational and the disturbance pressure and density  $p_2$  and  $\rho_2'$  do not vanish even when  $t < 0$ .

Across a free vortex sheet only the tangential component of the velocity can be discontinuous, and the discontinuity is related to the linear intensity of the sheet. We have,

$$[u_k] = -\sigma_k(s_k) \sin \alpha_k$$

and

$$[v_k] = -\sigma_k(s_k) \cos \alpha_k \quad (8)$$

where  $[ ]$  denotes the jump of the quantities across the vortex sheet from the lower surface to the upper surface. The relationships with  $k = 2$  are applicable to the portion of the vortex sheet which passes through the shock, and  $s_2$  is the arc length from the leading edge.

From the jump conditions across a free vortex sheet and the conservation laws across a shock wave, we shall determine the shape and the strength of the vortex sheet behind the shock wave in the next section.

### The Analysis

Since the motion of the free vortex sheet under the linearized theory is governed by the undisturbed flow, we will determine at first the inclination of the vortex sheet behind the shock.

From equations (5) and (6), we see that a point C on the vortex sheet, which was at an arc length  $s$

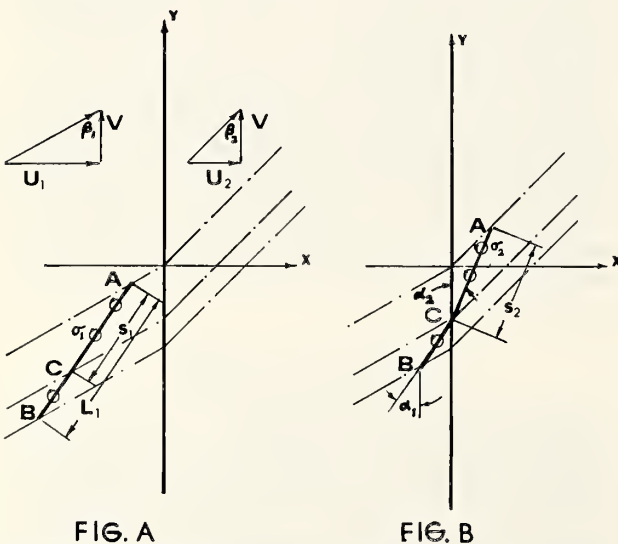


FIG. 1—Trajectory of the vortex sheet ACB: a) at  $t < 0$ ; b) at  $t = s_1 \sin \alpha_1 / U_1$  (undisturbed shock front along  $y$ -axis, — — — stream lines of the undisturbed flow).

behind the leading edge when  $t < 0$ , arrives at the shock front ( $x = 0$ ) at the instant,

$$t^* = s_1 \sin \alpha_1 / U_1 \quad (9)$$

while

$$y^* = Vt^* - s_1 \cos \alpha_1.$$

The leading edge moved during the interval  $t = 0$  to  $t = t^*$  behind the shock and arrived at the point  $(U_2 t^*, Vt^*)$ . The slope of the line segment AC behind the shock is

$$\cot \alpha_2 = \frac{V_1 t^* - y^*}{U_2 t^*} = \frac{s_1 \cos \alpha_1}{U_2 t^*} = \Lambda^{-1} \cot \alpha_1 \quad (10)$$

The slope is independent of  $s_1$ , therefore, the vortex sheet behind the shock is represented by the line segment AC in the  $x$ - $y$  plane. The arc length is

$$s_2 = |AC| = [(U_2 t^*)^2 + s_1^2 \cos^2 \alpha_1]^{1/2} \\ = s_1 [\cos^2 \alpha_1 + \Lambda^2 \sin^2 \alpha_1]^{1/2}. \quad (11)$$

In deriving equations (10) and (11) we make use of the fact that the velocity component, which is tangential to the shock, remains the same across the shock. Therefore, the tangential component of the line segment remains unchanged during its passage through the shock, while the normal component decreases by the factor  $U_2/U_1$ .

The disturbed shock surface can be represented by the equation

$$x = \epsilon \psi(y, t). \quad (12)$$

The unit normal vector  $\mathbf{n}$ , the tangential vector  $\boldsymbol{\tau}$  and the shock velocity  $U_s \mathbf{n}$  are related to  $\psi$  as follows

$$\mathbf{n} = \mathbf{i} - \epsilon \psi_y \mathbf{j}, \quad \boldsymbol{\tau} = \epsilon \psi_y \mathbf{i} + \mathbf{j} \quad (13)$$

and

$$U_s = \epsilon \psi_t. \quad (14)$$

The velocity components along the  $\mathbf{n}$  and  $\boldsymbol{\tau}$  directions relative to the disturbed shock front are

$$U_k + \epsilon(u_k - \psi_t - V\psi_y) \quad \text{and} \quad V_k + \epsilon(v_k + U_k \psi_y).$$

The tangential momentum equation across the shock yields

$$v_2(0^+, y, t) = V_1(0^-, y, t) \\ + (U_1 - U_2)\psi_y(y, t) \quad (15)$$

The linearized continuity, normal momentum and energy equations involve unknowns  $\rho_2'$ ,  $u_2$ ,  $p_2$ , and  $\psi$ . We can eliminate  $p_2$  and  $\rho_2'$ , and relate  $u_2$  to  $\psi$ ,

$$u_2(0^+, y, t) = u_1(0^-, y, t)(1 - A) \\ + (\psi_t + V\psi_y)A \quad (16)$$

where  $A = 2(M_1^2 + 1)/\{M_1^2(\gamma + 1)\}$ .

From equations (9) and (10) we see that the vortex sheet intersects the shock front at  $(0, y^*)$  with

$$y^*(t) = (V - U_1 \cot \alpha_1)t = (V - U_2 \cot \alpha_2) \quad (17)$$

If we apply equation (16) above and below the vortex sheet, i.e., at  $y = y^* + 0$  and  $y = y^* - 0$  respectively and then take their difference we obtain a shock relationship for the discontinuities across the vortex sheet,

$$[u_2] = [u_1](1 - A) + \{\psi_t + V\psi_y\}A \quad (18)$$

Similarly, we apply equation (15) at  $y = y^* + 0$  and  $y = y^* - 0$  respectively, and the difference of these two equations yields

$$[v_2] = [v_1] + (U_1 - U_2)[\psi_y] \quad (19)$$

The shock surface must be continuous, including the point of intersection with the vortex sheet. A discontinuity in shock surface across the vortex sheet creates a finite pressure difference across the sheet,  $p_2 - p_1 + 0(\epsilon)$ , which cannot be supported by the free vortex sheet. The  $x$ -coordinate of the point of intersection of the shock surface and the vortex sheet has to be a continuous function of  $y$ , i.e.

$$\psi(y^* + 0, t) - \psi(y^* - 0, t) = 0 \quad (20)$$

where  $y^*(t)$  is defined by equation (17). Differentiation of equation (20) with respect to  $t$  yields

$$[\psi_y](V - U_1 \cot \alpha_1) + [\psi_t] = 0 \quad (21)$$

We now eliminate  $[\psi_t]$  and  $[\psi_y]$  from equations (18), (19) and (21), and obtain

$$[u_2] = [u_1](1 - A) + A\{[v_2] \\ - [v_1]\}U_1 \cot \alpha_1 / (U_1 - U_2) \quad (22)$$

From equation (8) for a free vortex sheet and the kinematic condition (eq. 10), equation (22) yields the relationship between the strengths of the vortex sheet behind and ahead of the shock,

$$\sigma_2(s_2) = \sigma_1(s_1) \left\{ \frac{(1 - A)(1 - \Lambda) - A \cot^2 \alpha_1}{(1 - \Lambda) - (A/\Lambda) \cot^2 \alpha_1} \right\} \{\sin^2 \alpha_1 \\ + (\cos^2 \alpha_1)/\Lambda^2\}^{1/2} \quad (23)$$

Both  $\Lambda$  and  $A$  are defined in equations (3) and (16) as a function of  $M_1$ , which characterizes the shock strength.

### Concluding Remarks

We established conditions (eqs. 10 and 23) which define the shape and the strength of the vortex sheet after its passage through the shock front. In our derivation the vortex sheet is represented by a finite line segment inclined at angle  $\alpha_1$  with the shock front. Consequently the vortex sheet behind the shock is also a finite line segment inclined at angle  $\alpha_2$ . Since we employed only the conditions across the shock and those across the vortex sheet, our results can be applied to an infinitesimal line segment of a curved vortex sheet. Equation (10) relates  $\alpha_1$  and  $\alpha_2$  which now represent the angles between the vortex sheet ahead and behind the shock. Equation (23) then relates the linear strengths  $\sigma_1$  and  $\sigma_2$  of the vortex sheet across the shock front. Equation (11) which defines the change in the arc length from the leading edge of the vortex sheet becomes now a differential relationship

$$\frac{ds_2}{ds_1} = [\cos^2 \alpha_1 + \Lambda^2 \sin^2 \alpha_1]^{1/2}$$

and  $\alpha_1$  is, of course, a given function of  $s_1$ .

It is evident from equation (23) that for a given shock strength there is a critical angle  $\alpha_{cr}$ :



$$\alpha_{er} = \arccot \left[ \frac{\Lambda(1 - \Lambda)}{A} \right]^{1/2}$$

$$= \arccot \left\{ \frac{[(\gamma - 1) M_1^2 + 2] (M_1^2 - 1)}{(\gamma + 1) M_1^2 (M_1^2 + 1)} \right\}^{1/2} \quad (23)$$

when  $\alpha_1 \rightarrow \alpha_{cr}$ ,  $\sigma_2 \rightarrow \infty$ , and hence the linearized solution fails.

When we let  $y \rightarrow y^* \pm 0$  and obtained the relationships (18) and (19), we implied that the vortex sheet was the only discontinuity surface behind the shock. This is true when the flow field behind the shock is subsonic relative to the point C of intersection of the shock and the vortex sheet. The flow is subsonic when

$$M_2 \csc \alpha_2 < 1$$

when  $\alpha_2$  and  $M_2$  are expressed in terms of  $\alpha_1$  and  $M_1$ , the inequality becomes

$$\pi/2 \geq \alpha_1 > \mu$$

where

$$\mu = \arccot \left\{ \frac{(M_1^2 - 1) [2 + (\gamma - 1)M_1^2]}{(\gamma + 1) M_1^4} \right\}^{1/2}.$$

Since  $\cot \mu / \cot \alpha_{cr} = (M_1^2 + 1)^{1/2} / M_1 > 1$  we have  $\alpha_{cr} > \mu$ . Equation (23) is therefore valid when the angle  $\alpha_1$  between the incident vortex sheet and the shock wave lies between  $\mu$  and  $\pi/2$  except in the small neighborhood of  $\alpha_{cr}$ . For  $\alpha_1 \approx \alpha_{cr}$  we must include the nonlinear terms in order to obtain a theory uniformly valid near  $\alpha_{cr}$ . Certainly, experimental investigations for the case of  $\alpha_1 \approx \alpha_{cr}$  are of great interest. For  $\alpha_1 < \mu$ , the flow behind the shock relative to the point C is supersonic and we should include an additional discontinuity surface which is a Mach wave or

a weak shock from point C. These investigations will be reported later.

### Literature Cited

- Beckwith, I. E., A. J. Skokowski, W. D. Harvey, and P. C. Stainback. 1975. Design and preliminary test results at Mach 5 of an axisymmetric slot sound shield. NASA TMX-72679.
- Dosanjh, D. S., and T. H. Weeks. 1965. Interaction of a starting vortex as well as a vortex sheet with a traveling shock wave. *American Institute of Aeronautics and Astronautics Journal*. 3:216.
- Hollingsworth, M. A., and E. J. Richards. 1955. A Schlieren study of the interaction between a vortex and a shock wave in a shock tube. *Aeronautical Research Council Fluid Motion Subcommittee Report*. A.R.C. 17:985; F.M. 2323.
- Liepmann, H. W., and A. Roshko. 1957. *Elements of gasdynamics*. John Wiley, New York, New York.
- Lighthill, M. J. 1953. On the energy scattered from the interaction of turbulence with sound or shock waves. *Proceedings of the Cambridge Philosophical Society* 49, 531.
- Moore, F. K. 1954. Unsteady oblique interaction of a shock wave with a plane disturbance. *NACA Report* 1165.
- Moskvin, M. V. 1960. Note on the assessment of flow disturbances at a blunt body travelling at supersonic speeds owing to flow disturbances in free-stream. *J. Appl. Mech.* 27:223-229.
- Ribner, H. S. 1954. Convection of a pattern of vorticity through a shock wave. *NACA Report* 1164.
- Ribner, H. S. 1959. The sound generated by interaction of a single vortex with a shock wave. *Institute for Aerospace Studies, University of Toronto, Toronto, Canada*. Report 161.
- Ting, L. 1974. Transmission of singularities through a shock wave and the sound generation. *Physics of Fluids*. 17:8:1518-1526.
- Ting, L. 1975. The passage of a vortex sheet through a shock wave. *Modern Developments in Shock Tube Research*. Ed. by Goro Kaminoto, Kyoto University, Japan. 378-385.

# Notropis Cerasinus (Cope) Record from the Appomattox River Drainage

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Kenneth Dickson, assistant professor. Received B.S. (1966) and M.S. (1968) North Texas State U., and Ph.D. (1970) VPI & SU. Special research interests: Effects of pollutants on aquatic communities and automated biomonitoring systems.



Wayne Potter, graduate student. Received B.S. (1971) Cornell U. Special research interests: Larval fish taxonomy.

Kanawaha River Drainages. Jenkins et al. (1971) listed the crescent shiner from Cape Fear (probably introduced), the Roanoke (native), the James (native, but possibly introduced) and the Kanawha, above the falls (native), river drainages.

Virginia Commission of Game and Inland Fisheries (VCGIF) field survey records in 1953 established distributional records in Holiday Lake for the chain pickerel, *Esox niger* (Lesueur); white sucker, *Catostomus commersoni* (Lacepede); black bullhead, *Ictalurus melas* (Rafinesque); yellow bullhead, *I. natalis* (Lesueur); brown bullhead, *I. nebulosus* (Lesueur); pumpkinseed, *Lepomis gibbosus* (Linnaeus); warmouth, *L. gulosus* (Cavier); bluegill, *L. macrochirus* (Rafinesque); largemouth bass, *Micropterus salmoides* (Lacepede); and black crappie, *Pomoxis nigromaculatus* (Lesueur). VCGIF field studies in 1954 further established distributional records in Holiday Lake for the redbreast sunfish, *Lepomis auritus* (Linnaeus), and smallmouth bass, *Micropterus dolomieu* (Lacepede). These records do not represent the dominate ichthyofauna of central Piedmont streams in Virginia.

Station 1 on Holiday Creek, 1.5 km above Holiday Lake, has an average stream gradient of 10.2 m/km with predominantly cobble and pebble substrate sizes in riffles and shallow pools. Stations 2 and 3, respectively, on the upper Appomattox River are located 1.1 km above and 0.7 km below the confluence with Holiday Creek with an average stream gradient of 3.4 m/km (Figure 1).

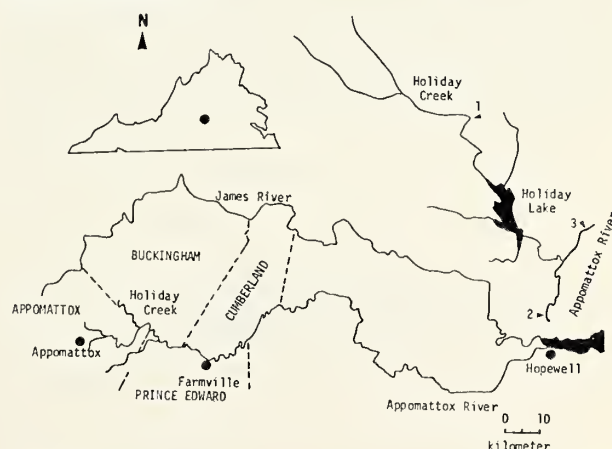


FIG. 1—Map of the Appomattox River and Holiday Creek locations.

The first record of the crescent shiner, *Notropis cerasinus* (Cope), being present in the Appomattox River system of the James River basin was established from collections in Holiday Creek, Appomattox and Buckingham Counties, Virginia, on June 10, 1976. Fifteen juvenile and three adult crescent shiners were collected in Holiday Creek upstream of Holiday Lake. Previous records showed the crescent shiner to range through parts of North Carolina, Virginia and West Virginia. Blair et al. (1968) and Eddy (1969) placed the distribution through the Roanoke and



TABLE 1  
Fish species collected from Holiday Creek and the upper  
Appomattox River.

Species	Station		
	1	2	3
<i>Anguilla rostrata</i>	—	—	×
<i>Esox niger</i>	×	—	×
<i>Campostoma anomalum</i>	×	×	—
<i>Clinostomus funduloides</i>	×	×	×
<i>Exoglossum maxillingua</i>	—	—	×
<i>Nocomis leptcephalus</i>	×	×	×
<i>Notropis analostanus</i>	—	—	×
<i>N. ardens</i>	×	—	—
<i>N. cerasinus</i>	×	—	—
<i>N. cornutus</i>	—	×	—
<i>N. rubellus</i>	—	—	×
<i>Chrosomus oreas</i>	×	×	—
<i>Rhinichthys atratulus</i>	×	×	×
<i>Semotilus atromaculatus</i>	×	—	—
<i>S. corporalis</i>	—	×	×
<i>Catostomus commersoni</i>	×	×	×
<i>Hypentelium nigricans</i>	×	—	—
<i>Moxostoma rhothoecum</i>	×	—	×
<i>Noturus insignis</i>	×	—	—
<i>Ambloplites rupestris</i>	—	—	×
<i>Lepomis gulosus</i>	×	—	—
<i>Etheostoma flabellare</i>	×	×	×
<i>E. longimanum</i>	—	—	×
<i>E. nigrum</i>	×	×	×
<i>E. vitreum</i>	—	×	×
<i>Percina peltata</i>	—	—	×
TOTAL SPECIES	16	11	17

Collections were made with a seine (3.6 m × 1.2 m × 0.64 cm) and by electrofishing. Each station on the creek and river was extensively sampled by both methods, except for Station 2, which was sampled only by electrofishing. Specimens were initially pre-

served in 10 percent formalin and later stored in 70 percent ethyl alcohol. All specimens, except those from Station 2 which were identified in the field, will be deposited in the Virginia Polytechnic Institute and State University fish museum.

Sixteen species of fish were collected from Holiday Creek (Table 1). Fifteen of these species were range extensions for Holiday Creek, and one species (*N. cerasinus*) was a new drainage record for the Appomattox River system. It was noted that the common shiner, *Notropis cornutus*, a closely related species to *N. cerasinus*, was not in collections from Holiday Creek, although it was collected from nine other tributaries of the upper Appomattox River during this project (Dickson and Abbott 1976). The presence of *Notropis cerasinus* in Holiday Creek probably resulted from a bait bucket release into the 58.7 ha recreational impoundment, Holiday Lake.

The information in this paper was taken from a survey conducted by the Center for Environmental Studies at VPI&SU for the U. S. Soil Conservation Service on the upper Appomattox River watershed. We wish to thank R. E. Jenkins, Roanoke College, Salem, Virginia, for confirmation of the species identity.

#### Literature Cited

- Blair, F. W., A. P. Blair, P. Bradkorb, F. R. Cagle, and G. A. Moore. 1968. Vertebrates of the United States. 2nd Edition McGraw-Hill, New York. 616 pp.
- Dickson, K. L., and T. M. Abbott. 1976. Water quality assessment of the upper Appomattox watershed in Virginia. Report to United States Department of Agriculture Soil Conservation Service, Richmond, Virginia. 125 pp.
- Eddy, S. 1969. How to know the freshwater fishes. 2nd Edition. William C. Brown Company, Dubuque, Iowa. 286 pp.
- Jenkins, R. E., E. A. Lachner, and F. J. Schwartz. 1971. Fishes of the central Appalachian drainages: their distribution and dispersal. In P. C. Holt, Editor. The distributional history of the biota of the southern Appalachians Part III: Vertebrates. Monograph 4. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. pp. 43-117.

## FEATURES

### Profile

#### Environmental Sciences Section

The section on *environmental sciences* is the fifteenth section of the Virginia Academy of Science. It was formed at the 52nd annual meeting of the Academy held on May 9–10, 1974 at Old Dominion University (ODU) through the combined efforts of Kuldip Chopra and Lewis Webb of ODU, William J. Hargis, Jr. of Virginia Institute of Marine Science (VIMS) and the late Roscoe Hughes of the Medical College of Virginia (MCV). Some good things have strangely unrelated and nocuous beginnings. Only two years earlier, Dr. Hughes had tried to form a section on *conservation of natural resources*, and apparently the time was not ripe.

Earlier in the year 1974, Hargis planted a seed in Chopra's mind regarding the desirability of starting a section on environmental sciences as part of the Academy. Stanley Ragone of VEPCO, then president of the Academy, brought Chopra and Roscoe Hughes together. A symposium on environmental sciences with emphasis on conservation of human and natural resources was organized for the session to form the section. It included presentations on air quality, visibility, wind and solar energy utilization, sea wave climate modeling, coastal zone management, land use, city planning, and environment and health. The symposium met a resounding success, and the environmental section was formed, with Chopra as the founding chairman.

During the following year, efforts of chairperson and Hughes led to an endowment fund set aside for undergraduate and graduate paper awards. The first Roscoe Hughes undergraduate award was presented by Mrs. Hughes in 1977. Since its formation, the section has offered very attractive programs at the Academy's annual meetings.

At the 53rd annual meeting held at *Madison College* in 1975, the section organized a full two-day program which highlighted a symposium on *impact of federal water pollution control act amendments* (co-sponsored by the engineering section), a frontiers in environmental science lecture on *Can Man Control the Weather* by internationally renowned Joanne Simpson, and sessions on oceanography from space, microscale circulations in waters, natural environment and health, meteorology, and air and water pollution. Fifty-seven leaders from 14 academic, industrial, state and federal governmental, and consumer organizations participated in the program which commanded record attendance leading to the confirmation of the section in the Academy.

The section maintained its vitality during the next two years. Two symposia and two contributed-paper sessions were organized for the 54th annual meeting held at *George Mason University* in 1976. The symposium on *environmental aspects of coastal zone management* attracted U.S. Senator Garland, B. C. Leysens (director of state planning and community affairs), John Sun (regional coordinator of NOAA's office of coastal zone management), Cranston Morgan (president, shell fish institute), and Scott Whitney (law professor at College of William and Mary). The second symposium on *environmental concerns of outer continental shelf development* included the participants: Congressman Robert Nibbock, Donald Boesch (VIMS), Francis Monastero (U.S. department of the interior), and Edward Wilson (Virginia Energy Office).

*Coastal environment, Virginia fisheries and estuarine studies* provided the principal themes for the symposium and sessions held at the 55th annual meeting at Virginia State College. Thirty-six specialists from 13 institutions made presentations. In spite of stiff competition from the symposium on the Mars Mission, cosponsored by all the other VAS sections, the symposium on *Virginia Fisheries: Managing a Living Resource* commanded an admirably large attendance.

The environmental sciences section appears to be moving dynamically in organizing strong programs which have a uniquely rare combination of academic and applied research with strong emphasis on interaction between science, man and environment. It seems to vigorously draw participants from among the leaders in our academic, consumer, industrial, research and governmental institutions within the Commonwealth, and from the administrative and legislative branches of the federal government. The section has developed a very attractive, two-day program with 28 presentations, including a symposium on *applications of science in coastal resource management* and another on *Measurements of ozone in Tidewater at the next annual meeting of the Academy at VPI & SU*.

Kuldip P. Chopra  
Founding Chairman of the Section  
Old Dominion University



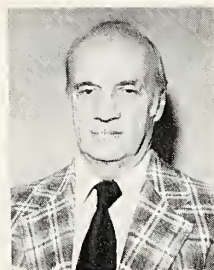
# NEWS, NOTES AND ANNOUNCEMENTS

## PRODUCTION EDITORS

The editor acknowledges with gratitude the excellent support he has received from our production editors, Ms. Alarie Tennille and Mr. Ernest M. Maygarden. The accuracy in copy-editing, proof-reading, and occasionally rewriting parts of manuscripts has resulted from the meticulous care with which they have handled the papers accepted for publication in the VJS. Several complimentary letters the editor has received from authors are truly the testimonials of their dedication to our journal.



Alarie Tennille, received her B.A. in English (1974) from the University of Virginia, and is a member of the *Phi Beta Kappa*. After being employed for two years as a *copy editor* in a law publishing firm, Ms. Tennille joined the staff of the Old Dominion University Research Foundation where she is an *information specialist*.



Ernest M. Maygarden, received his A.B. (1948) and A.M. (1949) from the University of Alabama. Prior to joining the Old Dominion University Research Foundation in 1972, he was an officer in the U.S. Air Force where he spent a number of years as a *technical intelligence analyst and editor of intelligence documentation* used in aerospace re-

search and development. He has been the *director of project administration* for the Research Foundation since 1975, and more recently has also served in the capacity of its *acting executive director*.

## VIRGINIA FLORA ATLAS

The first part of the Virginia Flora Atlas is now available. Compiled by A. M. Harvill, Jr., C. E. Stevens and D. M. E. Ware, it includes contributions by E. Berkeley, D. C. Bliss, and P. M. Mazzeo. The first floral atlas for Virginia ever published, it is a major contribution to the floristic knowledge of the Old Dominion.

This first part of the Atlas provides a general introduction, traces history of botanical exploration from the Colonial times to the present, and discusses physiography and geological history, cli-

mate and soils, vegetation types and plant communities, and phytogeography and vegetational history. It also includes distribution dot-maps for the various specific, and occasionally subspecific, taxa representing the ferns and their allies (Pteridophytes), cone-bearing plants and their relatives (Gymnosperms), and the three-parted flowering plants (Monocotyledons).

The Atlas may be purchased for \$3.85 from *Virginia Botanical Associates, Route 6, Box 130, Farmville, VA 23091*.

## SMITHSONIAN INSTITUTION FELLOWSHIPS

The Smithsonian Institution awards a few predoctoral and postdoctoral fellowships each year in support of independent research, pertaining to research interests of the Smithsonian research staff in residence at the Smithsonian using collections, facilities, and laboratories. Research areas include anthropology, biological sciences,

earth sciences, and history of science and technology. Additional information and application forms may be obtained from *Office of Academic Studies, Smithsonian Institution, Washington, D.C. 20560*.

### THIRD PHILIP MORRIS SCIENCE SYMPOSIUM

*Structures and biochemistry of natural biological systems* will be the theme of the third Philip Morris Science Symposium scheduled for November 9, 1978. The symposium consists of six invited lectures dealing with various aspects of natural-product science, including natural polymers, physical aspects of plant cell walls, enzyme systems, and reaction mechanisms.

The invited speakers are Paul J. Flory, 1974 Nobel Laureate, department chairperson and Jackson-Wood professor of chemistry at Stanford U.; Peter Albersheim, professor of molecular biology,

U. of Colorado; Robert H. Marchessault, department director and professor of chemistry, U. of Montreal; Britton Chance, Johnson professor of biophysics, U. of Pennsylvania; Daniel E. Koshland, Jr., professor of biochemistry, UC at Berkeley; and R. Malcolm Brown, professor of botany at UNC.

Inquiries for additional information may be addressed to *Karol G. Sharp, Philip Morris Research Center, P. O. Box 26583, Richmond, VA 23261.*

### SYMPOSIUM ON ENDANGERED AND THREATENED PLANTS AND ANIMALS

The Center for Environmental Studies at VPI & SU is planning a symposium on endangered and threatened plants and animals to be held at the Center on May 19-20, 1978. The cosponsors of the symposium are Department of Fisheries and Wildlife Sciences at VPI & SU; Virginia Commission of Game and Inland Fisheries; and Virginia Institute of Marine Science.

The primary purpose of the symposium is to generate a carefully considered, well-documented list of Virginia flora and fauna deemed endangered, threatened, or otherwise of concern. It is aimed to bring together conservationists, professional biologists, teachers, students, and interested laymen. All data compiled at the

symposium will form the basis of a comprehensive publication which will be available to all resource-oriented state and federal agencies, planners at a variety of levels, scientists and the citizens of Virginia.

The workshop sessions shall focus on plants, freshwater and terrestrial mollusks and anthropods, marine invertebrates, fishes, amphibians and reptiles, birds, mammals, and geographical areas of special concern.

Address inquiries for additional information to *Donald W. Linzey, Center for Environmental Studies, VPI & SU, Blacksburg, VA 24061.*

### ENGINEERING, ENVIRONMENTAL SCIENCES AND PSYCHOLOGY SECTIONS PLAN SYMPOSIA

Three sections have made plans for special symposia as part of their section's activities at the next annual meeting of the Virginia Academy of Science to be held at VPI & SU on May 11-12, 1978.

The *engineering section* has picked the theme *Water Quality Engineering—What Have We Learned from PL-500?* The panelists will be drawn from the academic, industrial, and governmental sectors.

The *environmental sciences section's* symposium will deal with the application of science in *Coastal Resource Management* with emphasis on erosion, land use of nonpoint pollution, and wetlands.

The *psychology section's* symposium has the title *Psychology in Virginia*. Chaired by professor emeritus William M. Hinton of Washington and Lee University, the symposium will include the following topics: history of psychology section (Frank Finger, U. VA), today's undergraduate programs (Frank Murray, R-M WC), master's level programs (Paul Woods, Hollins College), doctoral programs (James Dees, U. VA), Virginia Psychiatric Association perspectives (Robert Tipton, VPA), Virginia Board of Psychologists Examiners perspectives (Richard Abiden, VBPE), and a perspective on psychology in Virginia (B. von Haller Gilmer).



# THE VIRGINIA JOURNAL OF SCIENCE

## NOTES FROM VAS COUNCIL MEETING

HELD ON NOVEMBER 6, 1977

The Fall 1977 council meeting was convened at 1:45 p.m. at Piedmont Virginia Community College, Charlottesville, Virginia. In addition to President Ralph Lowry, the following council members and visitors were in attendance:

L. D. Abbott, K. P. Bovard, S. G. Bradley, B. M. Bruner, A. W. Burke, Jr., D. R. Carpenter, Jr., K. P. Chopra, E. M. Cliff, D. G. Cochran, W. Elias, Jr., V. C. Ellett, M. R. Escobar, S. T. Gamble, B. Harshbarger, G. H. Johnson, K. R. Lawless, P. M. Mazzeo, H. McKennis, Jr., W. B. Newbolt, A. B. Niemeyer, Jr., L. C. Parson, R. A. Paterson, W. A. Powell, V. B. Rensburg, G. R. Taylor, E. Thompson, E. F. Turner, Jr., D. V. Ulrich, W. R. West, Jr., J. E. White and E. L. Wisman.

### President's Report

#### *Annual Meeting*

Following a meeting with the local arrangements committee at VPI & SU, President Lowry reported that plans for the 1978 Annual Meeting were progressing well.

#### *Liaison Activities*

President Lowry attended the Virginia Teachers' Conference and extended greetings and welcome on behalf of the VAS. He also reported on an inquiry by the American Association for the Advancement of Science as to whether the VAS can provide 10 session conveners for the February 1978 AAAS meeting in Washington, D.C. President Lowry had expressed the Academy's willingness to help and was awaiting the AAAS' response to his reply.

### President-Elect's Report

President-elect Dale Ulrich distributed a schedule of responsibilities for the 1978 VAS/VJAS meeting and reported on some special planned activities for the May 9-12 event. A poster session will feature 30 4' x 4' posters. In addition, a conjoint meeting of the VAS with the Physics Department at Virginia Polytechnic Institute and State University is under consideration.

### Executive Secretary's Report

Blanton Bruner reported that the mailing of 1978 dues invoices was complete and that 331 VAS members had already paid. Of these, 43 chose to contribute to the research fund.

### Executive Committee Recommendations

The following recommendations were made to the Academy Council:

*1979 Meeting:* the committee recommended that next year's VAS meeting be held at the University of Richmond from May 8-11, 1979. The motion was passed.

*1980 Meeting:* the committee recommended that the meeting be held at the University of Virginia (during late April or early May 1980) subject to receipt of an official invitation. A motion for approval of the report was passed.

*1981 Meeting:* the committee recommended that a site visit be conducted of Randolph-Macon College and the Ashland area prior to preparation of a recommendation to Council pertaining to that college hosting the 1981 annual meeting. This recommendation is subject to a preliminary assessment of Randolph-Macon's endorsement of their invitation to host the meeting. The motion was passed.

*AAAS 1978 Annual Meeting:* the committee recommended that Drs. E. L. Wisman and Blanton Bruner attend this year's AAAS 1978 Annual Meeting in February.

### Report of the Editor, Virginia Journal of Science

Kuldip Chopra distributed a status report on the journal. He stressed the limited time frame for publication, emphasizing that all paper and draft submittals must proceed with clockwork precision to reach the printer in time for scheduled release days of April 30, July 31, August 31, and December 15 for the Spring, Summer, Fall and Winter issues, respectively. The Editor pointed out that the logistical problems associated with his duties provide the academy with three optional courses of future action. The first is for the Academy to provide logistic support to the Journal. The second option is to seek an Editor at an institution which is committed to providing full support. The third option is to discontinue publication of the Journal. Council decided that all efforts should be made to successfully provide adequate and consistent logistic support.

The Editor also recommended adoption of a "cost for reprints" policy whereby income from reprints balance, and not necessarily exceed, their production cost. Council moved unanimously that the Publications Committee review the Editor's suggested reprint cost schedule and submit their recommendation to the Council at the Spring 1978 meeting.

Projected production costs for the Journal during calendar year 1978 were estimated by the Editor and the Business Manager to be \$22,700.00 (for five issues).

### Report of the Director, Visiting Scientists Program

Gerald Taylor reported that 612 scientists made 972 topical presentations during the past year. The Director also requested that the Program's budget be increased from \$650.00 to \$750.00 to accommodate increased mailing costs.

### Reports of Standing Committees

*Awards Committee:* Reporting for the committee, Lynn Abbott placed the names of Blanton Bruner, Arthur Burke, Herbert McKennis, W. Allan Powell and Stanley Ragonc in nomination as Fellows of the Virginia Academy of Science. They were elected by the Academy Council.

D. Rae Carpenter moved that the Academy investigate the establishment of an ongoing award in honor of Dr. Jesse W. Beams. The motion passed.

*Finance and Endowment Committee:* Rae Carpenter, Committee Chairman, presented a tabular profile of past, present and proposed (FY 1978) budgets. Salient features were

1. A projected 1978 budget deficit, arising mainly from decreased income to the Virginia Journal of Science. He anticipated that the recent appointment of a Business Manager will lead to improvements, perhaps, through increased advertising revenues.
2. It was unanimously resolved to establish a special 14-member committee to study the Journal. The committee would comprise the following members: The Executive Committee (6 members), Finance Committee Chairman, Publication Committee Chairman, Fund-Raising Committee Chairman, Long Range Planning Committee Chairman, the Journal Editor and the Business Manager, and two immediate past presidents.

3. By unanimous council vote, it was decided to increase the 1978 Annual Meeting registration fees as follows:

\$5.00 Members (preregistration)  
\$7.00 Members (registration at door)  
\$10.00 Nonmembers

Student registration fees shall not change. This increase should provide approximately \$850.00 in additional income.

4. It was recommended that the Executive Secretary-Treasurer's salary be increased to \$3,000.00. The Council approved.
5. It was recommended that the contingency fund be reduced to \$400.00. This reflects Dr. Harvill's decision to independently publish the Virginia Flora Atlas and to decline the use of a \$2,000.00 VAS fund allocation for this publication.

*Junior Academy of Science Committee:* Reporting on behalf of chairperson John Hess, Dr. Donald Cochran reported the establishment of a new VJAS section on psychology. In addition, a recommendation from the committee that a limit of \$25.00 be placed on any annual awards from VAS sections to VJAS members was approved.

*Long Range Planning Committee:* Samuel Gamble presented the following three-part recommendation on behalf of chairperson Frank Flint:

1. That any section (including the VJAS) may choose to offer any internally funded (i.e.: funded by the particular section membership) awards, provided it appraises the chairman of the Awards Committee before the call for papers for the annual meeting is issued.
2. The following procedure should be followed by any section (including the VJAS) wishing to offer externally funded awards or prizes:
  - a. A communication to the Awards Committee, via the Academy President, expressing desire for offering this award or prize, the nature and criteria for it, and the proposed funding plan.
  - b. If the Awards Committee approves the request, the Academy President will seek counsel from the Executive Committee and/or other pertinent source to determine the feasibility and appropriateness of the proposed funding plan. He shall then inform the section chairperson regarding the proposal.
  - c. The section can then proceed to solicit those funds from outside its membership.

It was made clear that the intent of establishing the aforementioned procedure was related purely to the fund-solicitation phase and will not interfere with the section's prerogative and autonomy in selection of awardees. Council decided to adopt the recommendations.

*Research Committee:* Robert Paterson reported that six research proposals have been funded and four rejected.

*Virginia Flora Committee:* Peter Mazzeo reported that the Atlas of Virginia Flora had been published. He pointed out that the committee had been in existence since 1924 with the goal of preparing this Atlas, and now its future purpose needs to be clarified. A recommendation from the committee about its future is to be prepared for submittal to the Academy Council.

## Reports of Ad Hoc Committees

### Archives

Boyd Harshbarger reported that about 93 percent of VAS materials have been organized and catalogued in the "Virginia Academy" carrel in the VPI & SU library.

### Science Advisory

Ertle Thompson recommended that the Science Advisory System be formalized into a standing advisory committee of the Academy. He cited the following objectives of the system:

1. To provide scientific and technical advice to the Executive

and Legislative branches of state government, local governing bodies, and other state agencies.

2. To act as liaison among scientists and other individuals within state and local governments, industry, academic institutions and the lay citizenry to perform effectively an advisory role regarding social, political, economic, educational, scientific and technical problems in Virginia.
3. To identify broad future problems in all fields to which the scientific-technical knowledge should be applied to the search for solutions.
4. To define problem areas of immediate concern for short-range solutions.
5. To improve scientific/technical education at all levels.
6. To define more clearly goals for scientific research within the Commonwealth of Virginia.
7. To clarify the responsibilities for research activities and the application of scientific and technical knowledge among state and local governments, educational institutions and industries in Virginia.

Thompson also recommended that the standing committee, when instituted, should comprise a chairperson (appointed by the Academy President for a three-year term), three members-at-large (appointed by the President), the immediate past chairperson of each of the sections of the Academy, and one member elected at large from each section of the academy. Formalization of the standing committee would also necessitate an appropriate rephrasing of the aforementioned committee objectives.

Thompson also reported that Dr. Herbert McKennis and the advisory committee to Governor Godwin compiled a report on Laetrile, including a number of published materials.

Other committee activities included a presentation by Dr. William Hargis to the U.S. Senate Committee on the environmental impact of the Landsat remote sensing. Dr. Lowry, Dr. Thompson and a number of colleagues participated in the project review.

Dr. Thompson also reported that the National Science Foundation had provided the Commonwealth of Virginia with \$25,000.00 in November 1977. Dr. Donald Shull has been appointed as Science and Technology Coordinator to organize an effective science advisory system in the Commonwealth.

### Science Education

Art Burke reported outstanding attendance at the October 1977 'Science Teachers' workshop in Fredericksburg. The event was a joint effort sponsored by the Science Education committee, the State Department of Education, and the Virginia Association of Science Teachers.

## New Business

Edward Turner commented on the Academy's general approval of the concept of a permanent science advisory system, cautioning that many of the problems encompassed by this charge are broader than the academy's purview. In replying to an expressed reservation concerning the Academy's name being used within understandable limits, Arthur Burke noted that the Academy's role is to serve as a conduit to identifying qualified resource personnel and not to present or represent particular views. Rae Carpenter emphasized the delicate task of the Constitution and Bylaws Committee in preparing the phraseology of the amendments pertaining to this matter. Finally, President Lowry urged council members to contact Ertle Thompson on any aspects of the Science Advisory System's proposed incorporation as a standing committee.

The meeting was adjourned at 4:45 p.m.

Compiled by  
Michael N. Bishara  
Associate Editor, Science and Society



# REVIEWERS FOR VIRGINIA JOURNAL OF SCIENCE

- Anderson, G. M.  
*University of Toronto*
- Armstrong, David M.  
*University of Colorado*
- Armstrong, Tony W.  
*JRB Associates*
- Ash, Robert L.  
*Old Dominion University*
- Birdsong, Ray S.  
*Old Dominion University*
- Bishara, Michael N.  
*Southwest Virginia Community College*
- Black, Jr., Clanton C.  
*University of Georgia*
- Bogan, Michael  
*Nat'l. Fish & Wildlife Laboratory*
- Borgmann, Rolf E.  
*University of Georgia*
- Breedlove, Jack  
*Old Dominion University*
- Brooks, Jack  
*College of William & Mary*
- Browning, Fred M.  
*VCU—MCV*
- Campbell, Peter H.  
*University of North Carolina  
at Chapel Hill*
- Carlson, Carl E.  
*College of William & Mary*
- Carter, III, Rock O.  
*Old Dominion University*
- Chopra, Kuldip P.  
*Old Dominion University*
- Chaudhury, A. L.  
*Elizabeth City State University*
- Conley, Harold W.  
*Hampton Institute*
- Connor, Richard M.  
*VPI & SU*
- Cooper, Edwin L.  
*Pennsylvania State University*
- Costen, Robert E.  
*NASA Langley Research Center*
- Darby, Dennis A.  
*Old Dominion University*
- Day, Jr., Frank P.  
*Old Dominion University*
- DeVore, Thomas C.  
*James Madison University*
- Dillard, Gary  
*Western Kentucky University*
- Edwards, Gerald  
*University of Wisconsin*
- Grosch, Chester F.  
*Old Dominion University*
- Haley, Jr., Dillard R. C.  
*Department of Education, Virginia*
- Hall, Gustav  
*College of William & Mary*
- Harris, Thomas I.  
*Old Dominion University*
- Hawkridge, Fred M.  
*Virginia Commonwealth University*
- Hensley, Michael S.  
*Paul DeCamp Community College*
- Holloman, Rhoades  
*VPI & SU*
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- James, Frances C.  
*National Science Foundation*
- Janni, Joseph F.  
*Air Force Weapons Laboratory*
- Jenkins, Robert E.  
*Roanoke College*
- Johnson, Gerald H.  
*College of William & Mary*
- Johnson, W. Carter  
*Oak Ridge National Laboratory*
- Jones, Samuel B.  
*University of Georgia*
- Khandelwal, G. S.  
*Old Dominion University*
- Kiefer, Richard  
*College of William & Mary*
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Thermochemical calculations using Planck's free energy function and hydrothermal phase equilibrium data by *G. S. Khandelwal, J. P. Lescher and C. L. Patel*, Old Dominion University, Norfolk, Virginia.

Comparison of fish collection methods after rotenone application in New River, Virginia by *Michael T. Masnik, Jay R. Stauffer, Jr. and Charles H. Hocutt*, University of Maryland, Frostburg, Maryland.

Estimation of actuarial functions arising in coal mine valuation by *H. W. Gould*, West Virginia University, Morgantown, West Virginia.

Discrete mechanics for anisotropic potentials by *Robert A. Labudde*, Old Dominion University, Norfolk, Virginia and *Donald Greenspan*, University of Wisconsin, Madison, Wisconsin.

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Field work in Virginia's secondary school earth science classes by *Jack L. Mason*, Miami University, Oxford, Ohio.

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# Thermochemical Calculations Using Planck Free Energy Function and Hydrothermal Phase Equilibrium Data

G. S. Khandelwal, J. P. Lescher<sup>1</sup> and C. L. Patel<sup>2</sup>

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## Introduction

Fundamental properties of the thermodynamic generators are of continued interest in describing the physical properties of thermal systems. For instance, the thermodynamic generators, analogous to classical generators (Khandelwal 1971a, 1971b), can be shown to form relationships among themselves. One of the relationships is between  $U(V, S)$ , the internal energy;  $H(P, S)$ , the enthalpy;  $A(V, T)$ , the Helmholtz free energy; and  $G(T, P)$ , the Gibbs free energy. Similarly, a second group of generator Massieu functions,  $\Omega(P/T, T, U)$  and  $\psi(V, 1/T)$ , and Planck function  $K(P/T, 1/T)$  can be generated through the entropy function  $S(V, U)$  by Legendre transformations and a relationship between these four functions can be established. The Gibbs free energy, of the first group of generators, is widely used to describe properties of thermodynamic systems. It is expected that the Planck function, belonging to the second group of generators, due to its dependence on the appropriate variables, should be a rightful candidate for describing at least those processes which take place at constant temperature and pressure. The aim of this paper is to investigate the usefulness of the Planck function, in thermodynamic calculations, in the light of continuing study of the properties of the thermodynamic generators.

Recently, Fisher and Zen (1971) have given a method of calculating thermodynamic parameters of solid phases useful for geological processes. In this method, hydrothermal phase equilibrium data is utilized, and the resulting equation for the standard state molar Gibbs free energy of formation from the elements is obtained in terms of the entropy function. In the following we will obtain an equation for the standard state molar Gibbs free energy of formation from the elements in terms of the enthalpy function rather than in terms of the entropy function. In order to accomplish this, we consider Planck free energy function  $K$ , which is defined in terms of the entropy  $S$ , the enthalpy  $H$ , and temperature  $T$  as (Zemansky 1956):

$$K = S - \frac{H}{T}$$

The above equation in conjunction with the combined first and second laws of thermodynamics leads to the following differential form

**Abstract**—An equation for the standard state molar Gibbs free energy of formation from the elements is obtained in terms of the enthalpy function. The proposed approach is based on introducing the Planck free energy function. The Gibbs free energy of formation values for brucite and magnesium chlorite (clinochlore) are calculated to be  $-199,656 \pm 786$  cal mole<sup>-1</sup> and  $-1,974,112 \pm 2542$  cal mole<sup>-1</sup> respectively. These values are found to be in good agreement with the values reported by other authors.

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<sup>2</sup> Present address: Mosler Security & Electrical Systems, Wayne, N.J.

$$dK = \left(\frac{H}{T^2}\right) dT - \left(\frac{V}{T}\right) dP$$

where  $P$  and  $V$  refer to pressure and volume respectively.

It will be useful later to realize that Planck free energy  $K(T, P)$  is related to Gibbs free energy  $G$ , by

$$K = -\frac{G}{T}$$

Further, by comparing with results associated with Gibbs free energy,  $dK = \Delta K = 0$  at equilibrium,

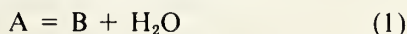
$$\left(\frac{\delta \Delta K}{\delta P}\right)_T = -\frac{\Delta V}{T}$$

and

$$\left(\frac{\delta \Delta K}{\delta T}\right)_P = \frac{\Delta H}{T^2}$$

### Thermodynamic Relations

To demonstrate the use of Planck free energy  $K(T, P)$  in calculating thermodynamic parameters, a reaction of the simple univariant dehydration type will be discussed. This reaction is represented by



At equilibrium,  $T = T_E$ ,  $P = P_E$ , and  $\Delta K = 0$ ; equation (1) then yields

$$\Delta K(T_E, P_E) = 0 = \Delta K_{f,B}(T_E, P_E) - \Delta K_{f,A}(T_E, P_E) + \Delta K_{f,H_2O}(T_E, P_E) \quad (2)$$

Also, for one mole of each phase, we note that

$$\Delta K_f(T_E, P_E) = \Delta K_f^0(298, 1) + \int_{T=298}^{T=T_E} \frac{\Delta H}{T^2} dT - \frac{1}{T_E} \int_{P=1}^{P=P_E} \Delta V dP \quad (3)$$

where  $\Delta K_f^0$  is the standard state molar Planck free energy of formation from the elements.

After extensive algebraic manipulations, the following<sup>3</sup> is obtained from equation (2):

$$\Delta K_{f,B}^0(298, 1) - \Delta K_{f,A}^0(298, 1) + \Delta H_{f,s} \left( \frac{1}{298} - \frac{1}{T_E} \right) - \frac{1}{T_E} \Delta V_s \Delta P + K_{H_2O}^*(T_E, P_E) = 0 \quad (4)$$

where

$$\begin{aligned} K_{H_2O}^*(T_E, P_E) &= \Delta K_{f,H_2O}^0(T_E, 1) \\ &+ \Delta K_{f,H_2O}(T_E, P_E) - \Delta K_{f,H_2O}(T_E, 1) \\ \Delta V_s &= V_{f,B} - V_{f,A} \\ \Delta H_{f,s} &= H_{f,B} - H_{f,A} \end{aligned}$$

and where  $V_f$  is the molar volume of formation from the elements.

In order to take advantage both of the tables compiled by Fisher and Zen and of standard thermodynamic data, it will be useful to express equation (4) in terms of Gibbs free energy. Employing the relationship  $K = -G/T$ , we obtain:

$$\begin{aligned} &\frac{\Delta G_{f,A}^0(298, 1)}{T} - \frac{\Delta G_{f,B}^0(298, 1)}{T} \\ &+ \Delta H_{f,s}^0 \left( \frac{1}{298} - \frac{1}{T_E} \right) \\ &- \frac{1}{T_E} \Delta V_s \Delta P - \frac{G_{H_2O}^*(T_E, P_E)}{T_E} = 0 \end{aligned} \quad (5)$$

where  $\Delta G_f^0$  is the standard molar Gibbs free energy of formation from elements.

### Examples

To demonstrate the use of equation (5) in calculating thermodynamic parameters, two simple examples will be considered.

Example 1: The first example is the one discussed by Fisher and Zen and is the reaction

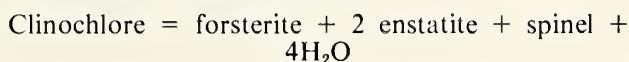


Fisher and Zen have given the values for most of the appropriate quantities appearing in equation (5). These are  $T_E = 877.15 \pm 3^\circ K$ ,  $P_E = 1000 \pm 10$  bars,  $T = 298^\circ K$ ,  $\Delta V_s(298, 1) = -0.31984 \pm 0.00084$  cal bar<sup>-1</sup>,  $G_{H_2O}^*(T_E, P_E) = -36385 \pm 109$  cal mole<sup>-1</sup>,  $\Delta P = 999 \pm 10$  bars,  $\Delta G_{f,B}^0(298, 1) = -136087 \pm 55$  cal mole<sup>-1</sup>. The value for  $\Delta H_{f,s}(298, 1) = 77,400 \pm 354$  cal mole<sup>-1</sup> was taken from the tables of Robie and Waldbaum (1968). Substituting these values in equation (5), we obtain for brucite

$$\Delta G_f^0 = -199,656 \pm 786 \text{ cal mole}^{-1}$$

The error figure reported here is twice the standard error to preserve consistency with the data from Robie and Waldbaum. This value of  $\Delta G_f^0$  for brucite should be compared with the value  $-199,500 \pm 790$  cal mole<sup>-1</sup> given by Robie and Waldbaum and with the value  $-200,040 \pm 690$  cal mole<sup>-1</sup> given by Zen and Fisher.

Example 2: We calculate the free energy of formation of magnesium chlorite (clinochlore) at  $298^\circ K$ , 1 bar for the following reaction between  $825 \pm 5^\circ C$  and  $837 \pm 5^\circ C$  at 10,000 bar water pressure as discussed by Bird and Anderson (1973):



Values for the appropriate quantities appearing in equation (5), with  $B$  representing the three separate species on the right-hand side of the reaction were calculated from the values of  $V_f$ ,  $H_f$ , etc., for these species given in the work of various authors. We list these values and corresponding authors from whose work they were calculated, in the following:

$$\Delta V_s = 1.56101 \pm 0.0032 \quad \text{Bird and Anderson (1973)}$$

<sup>3</sup> The calculational method and the relevant assumptions in arriving at this equation are essentially similar to those employed in Fisher and Zen (1971).



$$\Delta H_{f,s} = 316,550 \pm 1110$$

Robie and Waldbaum (1968); Zen (1972)

$$G_{H_2O}^* = 94,120 \pm 280$$

Fisher and Zen (1971)

$$\Delta G_{f,B}^0 = -1,713,687 \pm 490$$

Bird and Anderson (1973)

Substituting these values in equation (5) we obtain for magnesium chlorite:

$$\Delta G_f^0 = -1,974,112 \pm 2542 \text{ cal mole}^{-1}$$

Again, the error figure reported here is twice the standard error. The large error figure is due to generous estimates of error in data for  $\Delta H_{f,s}$  used in the calculations. This value of  $\Delta G_f^0$  for magnesium chlorite is in good agreement with the value  $-1,974,300 \pm 830 \text{ cal mole}^{-1}$  calculated by Bird and Anderson by applying the method of Fisher and Zen.

### Discussion

It is evident from the above examples that introducing Planck free energy may provide useful assistance in computing thermodynamic parameters. Besides providing a calculational ease for circumstances where entropy data is either missing or doubtful, the presentation in this paper may provide a useful check on the internal consistency of data in those cases where both entropy and enthalpy information is available.

An alternative derivation of eq. (5) can be carried out by employing the usual relationship between entropy and enthalpy in the corresponding equation

given in the work of Zen and Fisher. In this regard, this aspect of the present work is not intended to replace the original approach of Fisher and Zen, but is to be regarded as a supplement to it.

It is, however, now seen that the Planck function could indeed play a role in describing properties of real systems. Moreover, it is satisfying to know that the Planck function is the generator of the enthalpy term in equation (5). Further work is in progress in the study of equation (4) which involves the Planck function.

### REFERENCES

- Bird, G. H. and Anderson, G. M. (1973): The Free Energy of Formation of Magnesian Cordierite and Phlogopite. *Am. J. Sci.* **273**, 84-91.
- Fisher, J. R. and Zen, E-an (1971): Thermochemical Calculations From Hydrothermal Phase Equilibrium Data and the Free Energy of Formation of  $H_2O$ . *Am. J. Sci.* **270**, 297-314.
- Khandelwal, G. S. (1971a): The Classical Generating Functions. *Am. J. Phys.* **39**, 1267-1268.
- Khandelwal, G. S. (1971b): Generating Function for a Linear Harmonic Oscillator. *Am. J. Phys.* **40**, 476.
- Robie, R. A. and Waldbaum, D. R. (1968): Thermodynamic Properties of Minerals and Related Substances at 298.15°K (25°C) and 1 Atmosphere (1.013 bars) Pressure and Higher Temperatures. *U.S. Geol. Survey Bull.* **1259**, 256.
- Zemansky, M. W. (1956): Fifth Edition. *Heat and Thermodynamics*. McGraw-Hill Book Company, New York.
- Zen, E-an (1972): Gibbs Free Energy, Enthalpy, and Entropy of Ten Rock-Forming Minerals: Calculations, Discrepancies, Implications. *Am. Mineralogist*, **57**, 524-553.

# A Comparison of Fish Collection Methods after Rotenone Application in New River, Virginia

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**Abstract**—Previous work has demonstrated the desirability of utilizing a block net during rotenone application in a large river. An attempt was made at nine rotenone stations on the upper New River in North Carolina and Virginia to assess the relative efficiency of the use of a block net versus the use of personnel with dip nets. The block net was set, rotenone applied, and 6 experienced biologists using standard D-frame dip nets collected fish above the block net for a period of approximately 30 minutes. Use of the block net resulted in significantly higher numbers of species and specimens collected per locality than by dip netting alone. The most significant difference in capture frequency occurred in the *Etheostomatini* (Percidae) where 92 percent of all specimens taken was collected in the block net.

## Introduction

Lennon et al. (1970) and Schnick (1974) reviewed the use of rotenone in fisheries management. Schnick (1974) related that it was first used as a fisheries tool in the United States in 1934 and that by 1949, 34 states and several Canadian provinces were applying it to management and survey problems. By 1974, rotenone was available in the United States under 30 registration numbers representing 17 different companies on file with the U. S. Environmental Protection Agency in three basic formulations: 5 percent emulsifiable concentrate, 2.5 percent synergized emulsifiable concentrate and 5 percent wettable powder. Rotenone usefulness in fisheries research was demonstrated recently by Smith (1973), Hocutt, Hambrick and Masnik (1973), Hall (1974) and Chadwick (1976).

Hocutt et al. (1973) reported that less than 10 percent of the fish affected by rotenone was collected using dip nets when compared to the number collected in a block net located immediately downstream of the treated area. The estimation was based on qualitative field observations while sampling fish by rotenone in the New River, Virginia. The purpose of this study was to refine the above estimation with quantitative data and to determine the relative capture efficiency of each collection method for several families of fishes. Hocutt et al. (1973) related data on morphometry of New River.

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## Materials and Methods

The following methods for employing the block net in swift current were given in Hocutt et al. (1973). A 91 m  $\times$  3.6 nylon block net with 6.3-mm mesh was set downstream from the area to be rotenoned. Depending upon conditions (current velocity, substrate, etc.) a minimum width of 36 m was blocked with the net. Approximately 68 to 91 meters of river immediately upstream of the block net were treated with rotenone. Application of five percent powdered rotenone was made just above riffle areas whenever possible to facilitate mixing. Potassium permanganate was used to neutralize the rotenone below the block net. All collections were made in the upper New River (Figure 1).

Six experienced field biologists used standard D-frame kick nets to capture distressed and drifting fish within the treated area. No special instructions were given to the biologists as to the kinds of fish to collect, however, a bias to the collection of larger fish probably existed. Fish collected with the dip nets were placed in formalin as quickly as possible. At the end of the effective rotenone period, approximately 30 minutes after rotenone application, dip netting ceased and the block net was cleaned. Fish collected in the block net were preserved separately from the dip netted specimens. Preserved fish were sorted and placed in permanent storage in the Virginia Polytechnic Institute and State University fish collection. Numbers of specimens of each species collected by dip nets and block nets were recorded separately for each of the nine stations.

## Results and Discussion

A total of 6,381 specimens representing 36 species was collected during the investigation (Table 1), with the majority of taxa at each station taken in the block net (Table 2). At four stations the block net collected specimens of every species taken. In each of the other five instances, dip-netted samples increased the total number of species collected only by a single species. In each of these cases, the species not collected by the block net were represented by one or two large specimens that probably would have drifted into the block net if they were not dip netted.

Table 3 shows the number of specimens taken at each station and compares the relative (percent) efficiency of each collecting method. At each station, more specimens were taken by the block net than the dip nets alone. The percent of the total number of specimens taken at a station by dip nets ranged from 7 to 38 percent of the total, with an average of 14 percent for all 9 stations. This number is probably a high estimate since several of those specimens taken by dip nets would probably have drifted down to and become lodged in the block net. These data confirm the qualitative estimate of Hocutt et al. (1973) that 10 percent of the affected fish were caught with dip nets.

An unquantifiable bias exists in the study due to the passive nature of the block net. If the block net were not present, the composition of dip-netted samples would be unchanged; however, if dip netting were not conducted in conjunction with the block net, a significant portion of the specimens that appeared in the dip-netted samples would haveulti-

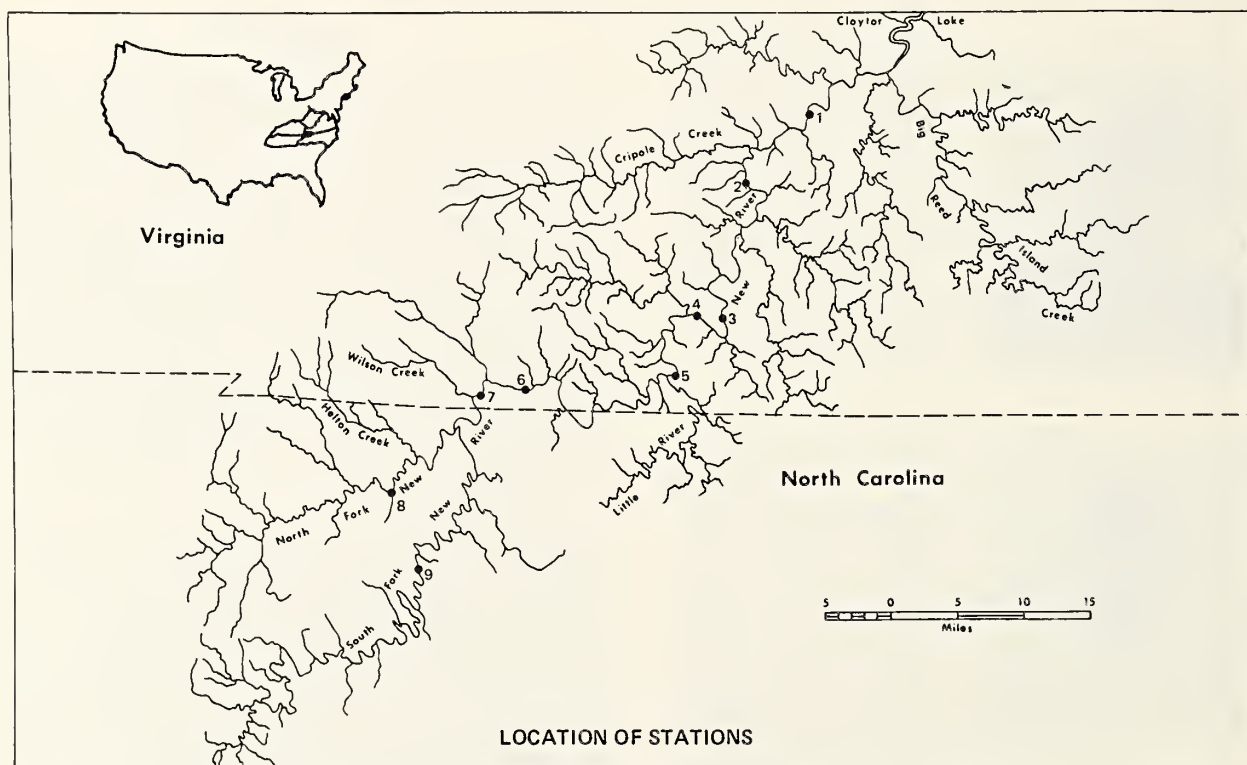


FIG. 1. Map of study area with fish sampling localities noted.

TABLE 1

Numbers of specimens by taxon collected during rotenone sampling by dip net (D) and block net (B) at each station

	STATION																	
	1		2		3		4		5		6		7		8		9	
	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B
Cyprinidae—Total	7	93	111	1912	311	1671	14	86	42	162	45	267	109	554	38	76	30	175
<i>Campostoma anomalum</i>				10		2						1	1	9		2	24	78
<i>Exoglossum laurae</i>															3	1		
<i>Nocomis leptcephalus</i>			7	28	24	20	2	38	7	12	26	83	60	155				1
<i>Nocomis platyrhynchus</i>	6	32	1	13	78	293	4	9	23	21	10	61	24	68	34	37		5
<i>Notropis albeolus</i>		1			34	157	1	1		13		1						
<i>Notropis ardens</i>			7	69														
<i>Notropis photogenis</i>		2						1					1	9		3	1	19
<i>Notropis rubellus</i>			59	1189	12	137		7	3	30	3	88	1	68	1	31		19
<i>Notropis rubricroceus</i>											1	3						
<i>Notropis scabriceps</i>		3		56	57	239		1		11	3	20	4	70				30
<i>Notropis spilopterus</i>	1	49	4	15	7	71	2	15	3	13		3		1			2	3
<i>Notropis volucellus</i>		6	28	458	28	318	5	11	3	58	1	2	6	71				
<i>Phenacobius teretulus</i>				5	28	237					1	1	9	82		2	1	1
<i>Pimephales notatus</i>			5	69	43	197		3	3	3			3	19				8
<i>Rhinichthys atratulus</i>														1			1	6
<i>Rhinichthys cataractae</i>										1		4						
<i>Semotilus atromaculatus</i>																		5
Castostomidae—Total	3	5	1	1	3	32	0	4	13	19	1	2	6	23	0	0	1	1
<i>Catostomus commersoni</i>													1					
<i>Hypentelium nigricans</i>	3	5	1	1	3	32		4	13	19	1	2	5	23			1	1
Ictaluridae—Total	2	0	6	9	4	2	2	0	6	4	0	1	0	0	0	0	0	0
<i>Ictalurus punctatus</i>						1												
<i>Pylodictis olivaris</i>	2		6	9	4	1	2		6	4		1						
Centrarchidae—Total	4	5	17	33	24	34	32	46	12	19	3	18	6	13	1	0	0	5
<i>Ambloplites rupestris</i>			13	26	22	29	27	30	8	15	3	18	4	8				3
<i>Lepomis auritus</i>							5	8										
<i>Lepomis cyanellus</i>				1														
<i>Lepomis gibbosus</i>										1								



TABLE 1 *continued*

	STATION																	
	1		2		3		4		5		6		7		8		9	
	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B
<i>Lepomis macrochirus</i>		1								1								
<i>Micropterus dolomieu</i>	3	3	4	6	2	5		8	2	2			1	4	1			2
<i>Micropterus punctulatus</i>	1	1											1	1				
<i>Pomoxis nigromaculatus</i>									2									
Percidae—Total	2	13	6	40	2	12	0	6	0	14	0	30	0	3	0	4	0	0
<i>Etheostoma blennioides</i>			1	8	2	2		1		1				1				
<i>Etheostoma flabellare</i>		1		9		8				3		6		2		4		
<i>Etheostoma kanawhae</i>	1	1		1						1								
<i>Percina caprodes</i>		1		1														
<i>Percina maculata</i>		1	4	17		2		1		1		15						
<i>Percina oxyrhyncha</i>	1	9	1	4				4		8		9						
Cottidae—Total	0	4	4	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cottus carolinæ</i> subsp.		4	4	83														

mately drifted into the block net. Therefore, the absence of specimens in the block net that only appeared in the dip-netted samples is not as significant as the converse. Specimens collected in the block net and not appearing in the dip-netted samples would have remained uncollected.

Catches of Cyprinidae, Centrarchidae, and Percidae were examined separately to evaluate the effect of different behavioral responses to rotenone treatment. These three families were chosen due to their differing reactions to the ichthyocide (Hocutt et al., 1973; Kinney, 1968). Behavior of the organisms after exposure to the rotenone would significantly influence the capture effectiveness of each collection method. Hocutt et al. (1973) stated that darters (Percidae: Etheostomatini) reacted immediately by erratic swimming on or just below the surface for a few seconds, then sinking immediately. Personnel using

dip nets would have a fairly short time to observe and capture these small specimens. Saltation along the bottom and entrainment in the river flow would ultimately carry many of the specimens downstream where they would become impinged on the net. Approximately 92 percent of the darters taken during the survey was collected in the block net, thus indicating that capture success with dip nets was minimal for this group (Table 1).

Hocutt et al. (1973) stated that other families of fish showed progressive resistance to the ichthyocide with cyprinids succumbing before centrarchids. Field observations have shown that both cyprinids and centrarchids come to the surface swimming erratically, demonstrating a decided loss of equilibrium. They often remain on or near the surface for a long time, thereby increasing the probability of capture by dip and block nets. Approximately 87 percent of the

TABLE 2

Number of species collected at each station by dip net and block net

	Station									All Stations Combined
	1	2	3	4	5	6	7	8	9	
Dip Net	8	15	14	8	11	9	14	4	6	28
Block Net	16	22	18	16	20	17	18	7	14	34
Total	17	22	18	17	21	17	19	8	14	36

TABLE 3

Percent of the total number of specimens taken at each station by dip net and block net

	Station									All Stations Combined
	1	2	3	4	5	6	7	8	9	
Dip Net	13	7	16	38	25	13	17	33	14	14
Block Net	87	93	84	62	75	87	83	67	86	86

total number of cyprinids and 63 percent of the centrarchids were taken by the block net. The higher percentage of cyprinids captured by the block net was probably because:

1. The great number of cyprinids present in the treated area resulted in many specimens drifting by the personnel using the dip nets;
2. The bias of the personnel using dip nets to collect large specimens or new taxa, primarily centrarchids, resulted in fewer affected centrarchids in the block net; and
3. Centrarchidae, as well as other large fish, can probably tolerate a higher concentration of the ichthyocide and, therefore, may revive to swim out of the net to avoid capture. However, capture is assured by dip net.

Three families, Catostomidae, Cottidae and Ictaluridae, exhibited different capture rates. Their low frequency of occurrence in the samples (less than four percent of all specimens collected) and their discontinuous distribution would not allow meaningful conclusions.

The conditions of fish collected with dip nets and with the block net differed. Specimens collected by the block net were in poor condition because they were subjected for a relatively long period to various stresses associated with impingement and asphyxiation. Dip-netted specimens, however, were almost immediately preserved to avoid loss from the dip net and are therefore more suitable for taxonomic purposes.

### Conclusions

The data suggest (1) that the block net captures more fish and more taxa in a given time period than six trained biologists employing dip nets and (2) that specimens in certain families, e.g., Percidae, may be lost when only dip netting is performed after ichthyocide application.

If a realistic qualitative and perhaps even quantitative picture of the fish community is to be gained

by the use of rotenone in stream investigations, the authors recommend that (1) a block net should always be used and (2) the number of personnel employed should depend on the difficulty of setting, cleaning and removing the block net, rather than on the collection of specimens with dip nets. However, dip netting should be performed since some taxa may not be collected by block net alone, and specimens collected in dip nets are better for taxonomic purposes.

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### Literature Cited

- Chadwick, E. M. P. (1976): Ecological Fish Production in a Small Precambrian Shield Lake. *Env. Biol. Fish.* 1, 13-60.
- Hall, G. E. (1974): Sampling Reservoir Fish Populations with Rotenone, *In*: Symposium on Methodology for the Survey, Monitoring and Appraisal of Fishery Resources in Lakes and Large Rivers. EIFAC/United Nations, Aviemore, Scotland, 14 pp.
- Hocutt, C. H., Hambrick, P. S., and Masnik, M. T. (1973): Rotenone Methods in a Large River System. *Arch. Hydrobiol.*, 72(2), 245-252.
- Kinney, E. C. (1968): Rotenone in Fish Pond Management. U. S. Bur. Spt. Fish. Wildl. Leaf. No. 576, 7 p.
- Lennon, R. E., Hunn, J. B., Schnick, R. A., and Burress, R. M. (1970): Reclamation of Ponds, Lakes and Streams with Fish Toxicants: a Review. FAO Fish. Tech. Pap. No. 100, 99 pp.
- Schnick, R. A. (1974): A Review of the Literature on the Use of Rotenone in Fisheries. FWS-LR-74/15, NTIS Coc. No. PB-235 454, 130 pp.
- Smith, C. L. (1973): Small Rotenone Stations: a Tool for Studying Coral Reef Fish Communities. *Am. Mus. Novitates*. No. 2512, 21 pp.



# Estimation of Actuarial Functions Arising in Coal Mine Valuation<sup>1</sup>

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**Abstract**—We evaluate and prove seven limits involving generalized Lambert series. The simplest of these is *Theorem 1*. For all real  $i_s > 0$ ,  $i_p > 0$ , then

$$\lim_{n \rightarrow \infty} A_n = (1 + i_p)/i_p^2,$$

where

$$A_n = \sum_{k=0}^{n-1} \frac{(1 + i_p)^{-k}}{i_p + \frac{i_s}{(1 + i_s)^{n-k} - 1}}$$

Here  $i_p$  is a speculative interest rate,  $i_s$  is a sinking fund rate,  $n$  is the number of years life of the mine, and  $A_n$  is used in a calculation of the value of the mine. The other sums involve an adjustment for future change of royalty rate so that the classical Hoskold formula (in use since 1877) may be applied to nonproducing property. The formulas appear in a new valuation method due to Donald M. Bondurant (thesis, engineering of mines, W. Va. Univ., 1974) allowing a better method of figuring ad valorem tax on mines. The method requires quick estimates such as given here in order to allow handy application. A handbook of tables is being published to make the results accessible to valuation engineers.

## 1. Introduction

For 100 years the principal method of mine valuation has been a formula set forth by Henry D. Hoskold (1877). Hoskold's formula determines the value of an annuity of future income using two inter-

est rates: (i) the risk rate for return of profit on investment, and (ii) the secure rate on sinking fund investment to replace the original investment.

The book *Mine Examination and Valuation* (Baxter and Parks, 1939, 1949) summarizes and illustrates the classic Hoskold method and is the popular reference and textbook on the subject.

While the Hoskold formula allows simplified computation of present worth for producing properties with a history of production and income, its application to nonproducing properties has very limited use since the determination of the deferred period prior to mining depends on variables of decision, technology and market.

What we have said above is drawn from a thesis by Donald M. Bondurant<sup>2</sup> who has translated the frustration over inability to apply mathematical precision to the valuation of nonproducing properties into a new set of formulas based in part on the Hoskold formula, but introducing an adjustment for future change of royalty rate. The resulting formulas are very complicated, involving as they do three interest rates, the number of years, and summations which cannot be simplified into a closed or single form. As part of a coal-related research project we have investigated several questions: limit forms, asymptotic forms, the computation of practical tables, and the general behavior for the Bondurant-Hoskold formulas. The limiting cases are the easiest to handle and are of practical use in that they give us precise upper bounds for the valuations. These limiting cases are expressible by amazingly simple formulas which we shall set forth below together with their mathematical proofs out of the Bondurant formulations. Our limit formulas can be calculated in a few seconds on any pocket electronic calculator to a high degree of accuracy. For a number of years that is small in comparison with the limiting case (about 100 to 400), the estimates are still best done by a large electronic computer, and computer programs for this purpose have just been devised by Mr. Stephen A. Ford, graduate assistant in the Department of Statistics and Computer Science at West Virginia University. Those programs are being used to produce tables and a handbook for practical engineering use.

Because of the complexity and newness of the formulas, it is important to carry out a theoretical study of the nature and behavior of the mathematical func-

<sup>1</sup> Prof. Gould received the J. Shelton Horsley Research Award of the Virginia Academy of Science in 1977 for findings contained in this article.

<sup>2</sup> M.S. thesis on 'design of a procedure for valuation of coal parcels for equitable ad valorem tax assessment,' W.Va. University (1974).

tions involved. Entirely apart from their practical use in tax assessment problems for mining, the new functions are a kind of generalized Lambert series not in any treatise or paper on series known to this author. Hence it develops that a practical problem has led to interest in a new kind of mathematical series whose properties may shed light on still other matters.

## 2. Hoskold and Bondurant Formulas

The Hoskold formula (or factor) is given by

$$H = \frac{1}{i_p + \frac{i_s}{(1+i_s)^n - 1}} \quad (2.1)$$

where:  $i_p$  = the speculative rate,  $i_s$  = sinking fund rate, and  $n$  = number of years of life of the mine. If then  $A$  = estimated annual earnings available for dividends and sinking fund, the worth of the mine,  $V$ , would be calculated from  $V = HA$ . See Baxter and Parks (1939, 1949). Davidson (1970), Hoskold (1877, 1903, 1905) and Schlauch and Lang (1942) for examples of use.

In contrast to this simple actuarial formula, Bondurant developed a method involving calculation of four complicated sums whose terms are related to the Hoskold factor. We may write the four sums as follows:

$$A_n = \sum_{k=0}^{n-1} \frac{(1+i_p)^{-k}}{i_p + \frac{i_s}{(1+i_s)^{n-k} - 1}}; \quad (2.2)$$

$$B_n = c_t \sum_{k=0}^{n-1} \frac{(1+c_t)^k(1+i_p)^{-k}}{i_p + \frac{i_s}{(1+i_s)^{n-k} - 1}}, \quad (2.3)$$

where  $c_t$  = production interest rate (a new factor introduced by Bondurant to take account of the increase in present worth due to a specified rate of change in production);

$$C_n = c_t \sum_{k=0}^{n-1} (k+1) \frac{(1+c_t)^k(1+i_p)^{-k}}{i_p + \frac{i_s}{(1+i_s)^{n-k} - 1}}; \quad (2.4)$$

and

$$D_n = c_t \sum_{j=1}^{n-1} \sum_{k=1}^j \frac{(1+c_t)^{k-1}(1+i_p)^{-j}}{i_p + \frac{i_s}{(1+i_s)^{n-j} - 1}}. \quad (2.5)$$

Actually, Bondurant combines  $C$  and  $D$  into one calculation, being concerned with the three quantities  $A_n$ ,  $B_n$ , and  $E_n$ , where

$$E_n = C_n + D_n, \quad (2.6)$$

but it is convenient to work with  $E$  separated into two parts.

We may now state our first result as a theorem about  $A_n$ . *Theorem 1.* For all real  $i_s > 0$ ,  $i_p > 0$ , the following limit exists with the indicated value:

$$\lim_{n \rightarrow \infty} A_n = \frac{1+i_p}{i_p^2}. \quad (2.7)$$

*Proof.* Our method of proof consists in first rewriting the series and then using a sequence of estimating techniques based on well-known inequalities. By rearranging the series as we do, we find that the proposed limit is the dominant term in an expansion of  $A_n$  that might be used to get an asymptotic formula. We have in fact, by putting  $n-1-k$  for  $k$ ,

$$\begin{aligned} A_n &= \sum_{k=0}^{n-1} (1+i_p)^{k-n+1} \frac{(1+i_s)^{k+1} - 1}{i_s - i_p + i_p(1+i_s)^{k+1}} \\ &= \frac{1}{(1+i_p)^{n-1}} \sum_{k=0}^{n-1} (1+i_p)^k \cdot \frac{(1+i_s)^{k+1} - 1}{i_p(1+i_s)^{k+1} - (i_p - i_s)} \\ &= \frac{1}{i_p(1+i_p)^{n-1}} \sum_{k=0}^{n-1} (1+i_p)^k \cdot \frac{(1+i_s)^{k+1} - 1}{(1+i_s)^{k+1} - (1 - i_s/i_p)} \\ &= \frac{1}{i_p(1+i_p)^{n-1}} \sum_{k=0}^{n-1} (1+i_p)^k \cdot \frac{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right) - \frac{i_s}{i_p}}{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right)} \\ &= \frac{1}{i_p(1+i_p)^{n-1}} \left\{ \sum_{k=0}^{n-1} (1+i_p)^k - \frac{i_s}{i_p} \sum_{k=0}^{n-1} (1+i_p)^k \frac{1}{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right)} \right\} \\ &= \frac{1}{i_p(1+i_p)^{n-1}} \left\{ \frac{(1+i_p)^n - 1}{i_p} - \frac{i_s}{i_p} \sum_{k=0}^{n-1} (1+i_p)^k \frac{1}{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right)} \right\} \\ &= \frac{1+i_p}{i_p^2} - \frac{1}{i_p^2(1+i_p)^{n-1}} \\ &\quad - \frac{i_s}{i_p^2} \frac{1}{(1+i_p)^{n-1}} \sum_{k=0}^{n-1} \frac{(1+i_p)^k}{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right)} \\ &= \frac{1+i_p}{i_p^2} - \frac{1}{i_p^2(1+i_p)^{n-1}} \\ &\quad - \frac{i_s}{i_p^2(1+i_p)^n} \sum_{k=0}^{n-1} \frac{(1+i_p)^{k+1}}{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right)} \end{aligned}$$



whence we have

$$A_n = \frac{1 + i_p}{i_p^2} - \frac{1}{i_p^2(1 + i_p)^{n-1}} \quad (2.8)$$

$$- \frac{i_s}{i_p^2(1 + i_p)^n} \sum_{k=1}^n \frac{(1 + i_p)^k}{(1 + i_s)^k - \left(1 - \frac{i_s}{i_p}\right)}.$$

What we see is that the first term subtracted here tends to 0, and we will prove that the term involving the summation also tends to 0 as  $n$  increases. Since  $A_n > 0$  we consider  $(1 + i_p)/i_p^2 - A_n$  and show that an upper bound for this tends to 0. This will establish the theorem. We have from equation (2.8)

$$(1 + i_p)/i_p^2 - A_n$$

$$\left\langle \frac{1}{i_p^2(1 + i_p)^{n-1}} + \frac{i_s}{i_p^2(1 + i_p)^n} \sum_{k=1}^n \frac{(1 + i_p)^k}{1 + ki_s - 1 + \frac{i_s}{i_p}} \right\rangle$$

where we have used the Bernoulli inequality to the effect that

$$(1 + y)^k > 1 + ky \text{ for integer } k > 1 \text{ and real } y > 0. \quad (2.9)$$

Therefore we have

$$\frac{1 + i_p}{i_p^2} - A_n < \frac{1}{i_p^2(1 + i_p)^{n-1}} + \frac{1}{i_p(1 + i_p)^n} \sum_{k=1}^n \frac{(1 + i_p)^k}{1 + ki_p}.$$

The summation here may be further overestimated by dropping the '1' in the denominator since  $1 + ki_p > ki_p$ , and so

$$\frac{1 + i_p}{i_p^2} - A_n < \frac{1}{i_p^2(1 + i_p)^{n-1}} + \frac{1}{i_p(1 + i_p)^n} \sum_{k=1}^n \frac{(1 + i_p)^k}{ki_p}$$

$$= \frac{1}{i_p^2(1 + i_p)^{n-1}} + \frac{1}{i_p^2(1 + i_p)^n} \sum_{k=1}^n \frac{(1 + i_p)^k}{k}.$$

We next invoke an inequality that says that if  $\{a_i\}$  and  $\{b_i\}$  are any two sequences of positive numbers with  $a_i$  steadily decreasing, and  $b_i$  steadily increasing, then

$$\sum_{k=1}^n a_k b_k < \frac{1}{n} \left( \sum_{k=1}^n a_k \right) \left( \sum_{j=1}^n b_j \right). \quad (2.10)$$

This is an immediate consequence of the identity

$$\left( \sum_{i=1}^n a_i \right) \left( \sum_{j=1}^n b_j \right) = n \sum_{k=1}^n a_k b_k$$

$$+ \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n (a_i - a_j)(b_j - b_i). \quad (2.11)$$

Inequalities of the type like equation (2.10) are due to

Tchebycheff, and the reader may consult Hardy, Littlewood and Polya (1934) for reference.

We apply equation (2.10) with  $a_k = 1/k$ ,  $b_k = (1 + i_p)^k$ . Since

$$\sum_{k=1}^n z^k = z \frac{z^n - 1}{z - 1},$$

then by setting  $z = 1 + i_p$  and simplifying, we get

$$\frac{1 + i_p}{i_p^2} - A_n < \frac{1}{i_p^2(1 + i_p)^{n-1}} + \frac{1}{i_p^2} \left\{ \frac{1 + i_p}{i_p} - \frac{1}{i_p(1 + i_p)^{n-1}} \right\} \frac{1}{n} \sum_{k=1}^n \frac{1}{k} \quad (2.12)$$

Now the harmonic series may be estimated, and in fact

$$\sum_{k=1}^n \frac{1}{k} = \log n + \gamma + O\left(\frac{1}{n}\right) \text{ as } n \rightarrow \infty, \quad (2.13)$$

where  $\gamma$  is Euler's constant 0.57721... A proof may be found in some calculus books and in almost any number theory text, e.g. LeVeque (1956). From equation (2.13) we have then

$$\frac{1}{n} \sum_{k=1}^n \frac{1}{k} = \frac{\log n}{n} + \frac{\gamma}{n} + O\left(\frac{1}{n^2}\right), \quad (2.14)$$

and since clearly  $\log n/n \rightarrow 0$  and  $\gamma/n \rightarrow 0$ , we find that

$$\lim_{n \rightarrow \infty} \frac{1}{n} \sum_{k=1}^n \frac{1}{k} = 0. \quad (2.15)$$

Since also  $(1 + i_p)^{1-n} \rightarrow 0$  as  $n \rightarrow \infty$ , then we have proved

$$0 < \frac{1 + i_p}{i_p^2} - A_n < \epsilon_n \text{ with } \epsilon_n \rightarrow 0 \text{ as } n \rightarrow \infty,$$

so the limit (eq. 2.7) follows, and our proof is complete.

Note that we used several estimates in arriving at equation (2.12). The overestimates are good enough to prove equation (2.7) but not very useful for estimating  $A_n$  for reasonably small  $n$ .  $A_n$  approaches its limit rapidly, so rapidly in fact that even for  $n = 200$  our upper bound conveys nothing useful about how close  $A_n$  is to its limit. We illustrate with  $i_p = 16$  percent, i.e.  $i_p = 0.016$ . Using the harmonic series approximation (eq. 2.14) we find

$$45.3125 - A_{200} < 5.8159 \times 10^{-12} + 39.0625(7.25 - 9.3055 \times 10^{-13})(0.0265)$$

or therefore

$$0 < 45.3125 - A_{200} < 7.5.$$

Since computations with a computer show that  $A_{200}$  is already in agreement with the limit 45.3125 to four decimals, it is obvious how poor the upper bound is for values of  $n$  other than  $\infty$ , even as big as 200. This shows that more study is needed to obtain approximations to  $A_n$  that yield handy and useful estimates. Nevertheless, the limit (eq. 2.7) is an absolute upper

bound beyond which  $A_n$  may not go, and so gives a quick bound for the numbers used to figure the worth of a mine by Bondurant.

One of the interesting things about our first theorem is the way in which the limit of  $A_n$  is entirely independent of  $i_s$ , the limit depending only on  $i_p$ . In fact, by using the Bernoulli inequality as we did,  $i_s$  cancelled out in our estimates at the first stage. The quantity  $i_s$  has an effect only for relatively small values of  $n$ . Use of the Bernoulli inequality seems to be where we make too big an overestimate for practical use with small values of  $n$ ; too many terms are dropped out in equation (2.9).

### 3. The Series $B_n$

Turning next to the series  $B_n$  we first make a rearrangement rather like what we did for  $A_n$ . We have

$$\begin{aligned} B_n &= \frac{c_t}{i_p(1+i_p)^{n-1}} \sum_{k=0}^{n-1} (1+c_t)^{n-1-k} (1+i_p)^k \\ &\quad \cdot \frac{(1+i_s)^{k+1} - 1}{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right)} \\ &= \frac{c_t(1+c_t)^{n-1}}{i_p(1+i_p)^{n-1}} \sum_{k=0}^{n-1} \frac{(1+i_p)^k}{(1+c_t)^k} \\ &\quad - \frac{i_s c_t (1+c_t)^{n-1}}{i_p^2 (1+i_p)^{n-1}} \sum_{k=0}^{n-1} \frac{(1+i_p)^k}{(1+c_t)^k} \\ &\quad \cdot \frac{1}{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right)} \end{aligned}$$

which, by use of the sum of a geometric series again, becomes finally

$$B_n = \frac{c_t(1 + i_p)}{i_p(i_p - c_t)} - \frac{c_t(1 + c_t)}{i_p(i_p - c_t)} \left( \frac{1 + c_t}{1 + i_p} \right)^{n-1} - \frac{i_s c_t}{i_p^2} \left( \frac{1 + c_t}{1 + i_p} \right)^n \sum_{k=1}^n \left( \frac{1 + i_p}{1 + c_t} \right)^k \cdot \frac{1}{(1 + i_s)^k - \left( 1 - \frac{i_s}{i_p} \right)} \quad (3.1)$$

We can state three theorems about  $B_n$ , depending upon how  $i_p$  and  $c_i$  are related. The first of these is as follows.

**Theorem 2.** If  $0 < c_t < i_p$ , then the following limit exists with the indicated value:

$$\lim_{n \rightarrow \infty} B_n = \frac{c_t(1 + i_p)}{i_p(i_p - c_t)} \quad (3.2)$$

*Proof.* Since  $1 + i_p > 1 + c_t$ , write  $(1 + i_p)/(1 + c_t) = 1 + z$ , with  $z > 0$ . Then  $1/(z + 1) < 1$  and so in equation (3.1), the first subtracted term

$$\frac{c_t(1+c_t)}{i_n(i_n-c_t)} \left(\frac{1}{1+z}\right)^{n-1} \rightarrow 0 \text{ as } n \rightarrow \infty.$$

As for the series term, we proceed as we did with  $A_n$ . We find

$$\frac{i_s C_t}{i_p^2} \frac{1}{(1+z)^n} \sum_{k=1}^n (1+z)^k \frac{1}{(1+i_s)^k - \left(1 - \frac{i_s}{i_p}\right)}$$

$$< \frac{i_s C_t}{i_p^2} \frac{1}{(1+z)^n} \sum_{k=1}^n (1+z)^k \frac{1}{1 + ki_s - 1 + \frac{i_s}{i_p}},$$

by Bernoulli's inequality,

$$= \frac{c_t}{i_p} \frac{1}{(1+z)^n} \sum_{k=1}^n \frac{(1+z)^k}{1+ki_p} < \frac{c_t}{i_p} \frac{1}{(1+z)^n} \cdot \sum_{k=1}^n \frac{(1+z)^k}{ki_p}$$

$$= \frac{c_t}{i_p^2} \frac{1}{(1+z)^n} \sum_{k=1}^n \frac{(1+z)^k}{k} \rightarrow 0, \text{ as } n \rightarrow \infty,$$

by the same estimate (eq. 2.10) and limit (eq. 2.15) we used before. Thus the limit (eq. 3.2) follows.

Next we state

*Theorem 3.* If  $c_t = i_p$ , then  $B_n$  is unbounded and diverges, and in fact

$$\lim_{n \rightarrow \infty} \frac{B_n}{n} = 1, \text{ or that is } B_n \sim n \text{ as } n \rightarrow \infty. \quad (3.3)$$

*Proof.* We cannot use formula (3.1) since  $i_p - c_t = 0$  would occur in a denominator. Set  $c_t = i_p = x$ . We have  $i_a > 0$ .

Now  $B_n > 0$  since  $(1 + i_g)^{n-k} > 1$  in equation (2.3), and

$$\begin{aligned} B_n &= x \sum_{k=0}^{n-1} \frac{1}{x + \frac{i_g}{(1+i_g)^{k+1} - 1}} \\ &= x \sum_{k=1}^n \frac{1}{x + \frac{i_g}{(1+i_g)^k - 1}} \\ &= x \sum_{k=1}^n \frac{(1+i_g)^k - 1}{x(1+i_g)^k - x + i_g} \\ &= \sum_{k=1}^n \frac{(1+i_g)^k + 1}{(1+i_g)^k - \left(1 - \frac{i_g}{x}\right)} \\ &= \sum_{k=1}^n \frac{(1+i_g)^k - \left(1 - \frac{i_g}{x}\right) - \frac{i_g}{x}}{(1+i_g)^k - \left(1 - \frac{i_g}{x}\right)} \\ &= \sum_{k=1}^n \left\{ 1 - \frac{\frac{i_g}{x}}{(1+i_g)^k - \left(1 - \frac{i_g}{x}\right)} \right\} \end{aligned}$$



$$= n - \frac{i_s}{x} \sum_{k=1}^n \frac{1}{(1+i_s)^k - \left(1 - \frac{i_s}{x}\right)} > 0 \text{ (recall)}$$

from which it is then evident that

$$\begin{aligned} 0 < n - B_n &= \frac{i_s}{x} \sum_{k=1}^n \frac{1}{(1+i_s)^k - \left(1 - \frac{i_s}{x}\right)} \\ &= i_s \sum_{k=1}^n \frac{1}{x(1+i_s)^k - (x-i_s)} \\ &< i_s \sum_{k=1}^n \frac{1}{x + kxi_s - x + i_s}, \end{aligned}$$

by Bernoulli's inequality,

$$= \sum_{k=1}^n \frac{1}{kx + 1}.$$

Dividing through by  $n$  we find the inequality

$$0 < 1 - \frac{B_n}{n} < \frac{1}{n} \sum_{k=1}^n \frac{1}{kx + 1}. \quad (3.4)$$

But

$$\sum_{k=1}^n \frac{1}{kx + 1} < \sum_{k=1}^n \frac{1}{kx},$$

whence we have

$$0 < 1 - \frac{B_n}{n} < \frac{1}{nx} \sum_{k=1}^n \frac{1}{k}. \quad (3.5)$$

Again invoking equation (2.15), we have the desired result so that relation (3.3) does indeed follow.

The case when  $c_t > i_p$  seems to require quite another approach. We use a series comparison technique and prove

*Theorem 4.* With  $c_t > i_p$  and setting  $w = (1 + c_t)/(1 + i_p) > 1$ , then  $B_n$  diverges and in fact  $B_n = O(w^n)$  as  $n \rightarrow \infty$ . More precisely,

$$\lim_{n \rightarrow \infty} \frac{B_n}{w^n} = \frac{c_t}{i_p} K \text{ for some } K > 0. \quad (3.6)$$

*Proof.* We return to definition (2.3) and, after some manipulations, find

$$\begin{aligned} B_n &= \frac{c_t}{i_p} w^n \sum_{k=1}^n w^{-k} \frac{(1+i_s)^k - 1}{(1+i_s)^k - \left(1 - \frac{i_s}{i_p}\right)} \\ &= \frac{c_t}{i_p} w^n \sum_{k=1}^n w^{-k} \frac{1}{1 + \frac{i_s}{i_p}[(1+i_s)^k - 1]} \end{aligned}$$

Now,  $(1+i_s)^k$  is strictly increasing for  $k \geq 1$ , so also then is  $(1+i_s)^k - 1$ . Then  $i_s/i_p[(1+i_s)^k - 1]$  is strictly decreasing, and so the factor

$$\frac{1}{1 + \frac{i_s}{i_p}[(1+i_s)^k - 1]}$$

is increasing, and one can show that it is  $< 1$ , and in fact tends to 1 as  $k \rightarrow \infty$ . Thus we have really

$$w^{-n} B_n = \frac{c_t}{i_p} \sum_{k=1}^n K_k w^{-k} \quad (3.8)$$

where  $\{K_k\}$  is a strictly increasing sequence with  $0 < K_k < 1$ , in fact  $\lim K_k = 1$  as  $k \rightarrow \infty$ , and  $0 < 1/w < 1$ . Now the series

$$\sum_{k=1}^n w^{-k} \quad (3.9)$$

converges as  $n \rightarrow \infty$  when  $0 < 1/w < 1$ , and so we may use it as a comparison series, for any fixed  $w$ , whence we see that the series in equation (3.8) converges, say to  $K$ . This then proves the theorem.

#### 4. The Series $C_n$

Turning next to definition (2.4), we find

$$C_n = c_t \sum_{k=0}^{n-1} k \frac{(1+c_t)^k(1+i_p)^{-k}}{i_p + \frac{i_s}{(1+i_s)^{n-k} - 1}} + B_n.$$

Therefore

$$\begin{aligned} C_n - B_n &= \frac{c_t(1+c_t)^{n-1}}{i_p(1+i_p)^{n-1}} \sum_{k=0}^{n-1} (n-1-k) \left( \frac{1+i_p}{1+c_t} \right)^k \\ &\quad - \frac{i_s c_t (1+c_t)^{n-1}}{i_p^2 (1+i_p)^{n-1}} \sum_{k=0}^{n-1} (n-1-k) \frac{(1+i_p)^k}{(1+c_t)^k} \\ &\quad \cdot \frac{1}{(1+i_s)^{k+1} - \left(1 - \frac{i_s}{i_p}\right)} \end{aligned} \quad (4.1)$$

The first term on the right can be summed in closed form since

$$\sum_{k=0}^{n-1} (n-1-k)u^k = \frac{u^n - 1}{(u-1)^2} - \frac{n}{u-1},$$

and we ultimately find

$$\begin{aligned} C_n - B_n &= \frac{c_t}{i_p} \frac{(1+i_p)(1+c_t)}{(i_p - c_t)^2} \\ &\quad - \frac{c_t}{i_p} \left( \frac{1+c_t}{1+i_p} \right)^{n-1} \frac{(1+c_t)^2}{(i_p - c_t)^2} \\ &\quad - n \frac{c_t}{i_p} \left( \frac{1+c_t}{1+i_p} \right)^{n-1} \frac{1+c_t}{i_p - c_t} - R_n, \end{aligned} \quad (4.2)$$

where  $R_n$  is the summation with factor on right side of equation (4.1). Again, under various conditions we may infer results. We shall content ourselves here with the case  $0 < c_t < i_p$ . Then we have  $(1+c_t)/(1+i_p) < 1$ , and the first two subtracted terms in equation (4.2) vanish as  $n \rightarrow \infty$ . By another tedious argument one can show that  $R_n \rightarrow 0$  as  $n \rightarrow \infty$ , and thus we are led to state

*Theorem 5.* When  $0 < c_t < i_p$ , the following limit exists with the indicated value:

$$\begin{aligned}\lim_{n \rightarrow \infty} C_n &= \lim_{n \rightarrow \infty} B_n + \frac{c_t}{i_p} \frac{(1 + i_p)(1 + c_t)}{(i_p - c_t)^2} \\ &= \frac{c_t(1 + i_p)^2}{i_p(i_p - c_t)^2}, \text{ by theorem 2.}\end{aligned}\quad (4.3)$$

In the other two cases,  $c_t = i_p$  and  $c_t > i_p$ , one expects to get asymptotic growth results. We omit the details here.

### 5. The Series $D_n$ and $E_n$

We consider the definition (2.5). In spite of the formidable appearance of a double sum, it is easy to reduce it to sums already studied here. Observe that

$$\sum_{k=1}^j (1 + c_t)^{k-1} = \sum_{k=0}^{j-1} (1 + c_t)^k = \frac{(1 + c_t)^j - 1}{c_t} = 0 \quad \text{for } j = 0,$$

by simple geometric series, whence the series (2.5) becomes

$$\begin{aligned}D_n &= c_t \sum_{j=1}^{n-1} \frac{(1 + i_p)^{-j}}{i_p + \frac{i_s}{(1 + i_s)^{n-j} - 1}} \cdot \frac{(1 + c_t)^j - 1}{c_t} \\ &= \sum_{j=0}^{n-1} \frac{(1 + c_t)^j (1 + i_p)^{-j}}{i_p + \frac{i_s}{(1 + i_s)^{n-j} - 1}} - \sum_{j=0}^{n-1} \frac{(1 + i_p)^{-j}}{i_p + \frac{i_s}{(1 + i_s)^{n-j} - 1}} \\ &= \frac{1}{c_t} B_n - A_n\end{aligned}$$

whence we have the simple result

$$D_n = \frac{1}{c_t} B_n - A_n. \quad (5.1)$$

Since, moreover, the final formula is  $E_n = C_n + D_n$ , we have finally

$$E_n = C_n + \frac{1}{c_t} B_n - A_n. \quad (5.2)$$

Putting in the limiting values for A, B, and C when  $c_t < i_p$ , we obtain

*Theorem 6.* For  $0 < c_t < i_p$ , the following limit exists with the indicated value:

$$\lim_{n \rightarrow \infty} D_n = \frac{c_t(i_p + 1)}{i_p^2(i_p - c_t)}. \quad (5.3)$$

Similarly then, we also have

*Theorem 7.* For  $0 < c_t < i_p$ , the following limit exists with the indicated value:

$$\lim_{n \rightarrow \infty} E_n = \frac{(1 + i_p)c_t}{i_p^2(i_p - c_t)^2} \{(i_p + 1)^2 - (1 + c_t)\}. \quad (5.4)$$

### 6. Some Numerical Examples

We consider the examples arising when  $i_p = 16$  percent = 0.16,  $i_s = 8$  percent = 0.08,  $c_t = 7$  percent

= 0.07, and  $n \rightarrow \infty$ . For  $n = 1(1)400$ , Bondurant gives values of  $A_n$  and  $B_n$  for these percentages. For  $E_n$  he gives values for  $n = 1(1)130$ . In the first two cases,  $A_n$  and  $B_n$  have just about settled to their limits at  $n = 400$ . In the case of  $E_n$  the computer used was not efficient and computation was halted before confirmation of the first decimal place. Here then are values from our formulas and comparisons with early computer values. The presently developed limit formulas were calculated on a Hewlett-Packard HP-35 pocket calculator.

TABLE 1  
Some numerical values with  $i_p = 0.16$ ,  $i_s = 0.08$ ,  $c_t = 0.07$  and  $n \rightarrow \infty$

QUANTITY	BY PRESENT FORMULAS	BY SLOW COMPUTER
$A_\infty$	45.3125 (exactly)	45.3125 ...
$B_\infty$	5.63888888	5.6389 ...
$C_\infty$	72.67901234	not given
$D_\infty$	35.2430555	not given
$E_\infty$	107.92206789	107.774 (inexact)

Later calculations on an IBM 360 agree with our results.

### 7. Conclusions and Suggestions for Further Research

We have studied complicated functions arising in actuarial work done in figuring tax levies on coal mine property using the Bondurant extension of the classic Hoskold formula. The behavior of these functions for indefinitely large values of  $n$  (number of years) has been completely determined, resulting in simple easy-to-compute formulas, readily amenable to any pocket calculator.

What remains to be done is to make the estimations more precise, say for  $n = 10$  to 100. This, however, is not such a bad situation since computer programs (in Fortran and PL-1) devised very recently by Stephen Ford allow very rapid calculation of the formulas.

From the point of view of pure mathematics, the asymptotic analysis is still important, in order to understand more fully the nature of the series involved.

In some of the work reported here, series of the general form and for some function  $f$

$$S(x, y, z, n; f) = \sum_{k=0}^n \frac{x^k}{z^k + y} f(k) \quad (7.1)$$

are suggested. For  $n = \infty$ ,  $z = x$ , and  $y = -1$ , the series is the classical Lambert series which enters extensively into certain parts of the theory of numbers.

It is also believed that an approach other than our method with the Bernoulli inequality will be discovered and will give better asymptotic results, or error estimates.

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## 9. Addendum: Use of Bondurant-Hoskold Formulas

We append here the precise way in which the new formulas are used in figuring valuations of mining property.

The complete valuation formula is

$$P_0 = X(H_n + c_r A_n + B_n + c_r E_n), \quad (9.1)$$

where  $A_n$ ,  $B_n$ , and  $E_n$  are as defined earlier, and:

$H_n$  = standard Hoskold factor

$$= \frac{1}{i_p + \frac{i_s}{(1 + i_s)^n - 1}},$$

$X$  = initial income from coal-producing property  
=  $T \cdot R$ ,

$T$  = coal production in tons,

$R$  = royalty rate in dollars per ton,

$n$  = total number of active production years in life of coal property,

$i_s$  = redemptive interest for sinking fund,

$i_p$  = speculative interest rate on investment,

$c_r$  = real worth rate of change in the royalty rate,

$c_t$  = rate of change in coal production,

$P_0$  = net present worth of mining property.

In a *Handbook of Valuation* (by Donald Bondurant, Stephen Ford, Henry Gould, and Michael Watts) now in press, values of  $A_n$ ,  $B_n$ , and  $E_n$  are tabulated for steps of 1 percent with  $5\% \leq i_s \leq 8\%$ ,  $10\% \leq i_p \leq 24\%$ ,  $7\% \leq c_t \leq 12\%$ , and subject to standard valuation assumptions of  $2i_s \leq i_p \leq 3i_s$ , with  $n$  given in steps of 1 year from  $n = 1$  through  $n = 400$ . The *Handbook* also presents the computer programs for calculation of the formulas and computer-generated graphs which show the behavior of the formulas.

In the absence of the *Handbook* or access to a large electronic computer, the field engineer may estimate the values of  $A_n$ ,  $B_n$ , and  $E_n$  by use of the seven theorems given earlier in the main body of the present paper.

If  $n$  is very large,  $H_n$  may be overestimated by  $1/i_p$ , since  $H_n < 1/i_p$  and tends to this as a limit as  $n \rightarrow \infty$ .

We now give five examples of valuation applications for typical mining properties. Four examples are based on tables; the last example uses one of the approximate formulas of Gould.

## 10. Examples of Valuation

### Example 1.

An analysis of coal properties in Keystone County reveals the following facts. Using the Bondurant-

Hoskold formula, what is the net present value of these properties?

$T = 55,000,000$  tons production at a constant rate for 75 years until exhaustion of coal reserves ( $c_t = 0$ );

$R = \$0.60$  per ton royalty rate increasing 3% per year ( $c_r = 0.03$ );

$X = T \cdot R = \$33,000,000$  initial income;

$i_s = 8\%$  (0.08), and  $i_p = 16\%$  (0.16).

The present value then must be  $P_0 = X(H_n + c_r A_n) = 33,000,000 [6.24026 + (0.03)(45.31193)] = \$250,787,400$ .

### Example 2.

Conditions the same as in Example 1 except that production is expected to double every 10 years ( $c_t = 0.07$ ), and royalty rate remains constant at  $\$0.60$  per ton ( $c_r = 0$ ). Present worth now must be  $P_0 = X(H + B_n) = 33,000,000(6.24026 + 5.62671) = \$391,610,000$ .

### Example 3.

Now assume that  $c_r = 0.03$  and  $c_t = 0.07$ . Present worth calculations become (again  $n = 75$ )

$$\begin{aligned} P_0 &= X(H_n + c_r A_n + B_n + c_r E_n) \\ &= 33,000,000[6.24026 + (0.03)(45.31193) \\ &\quad + 5.62671 + (0.03)(106.66624)] \\ &= \$542,068,400. \end{aligned}$$

Note: In each of these examples we have rounded the final answer to seven significant figures.

These examples show how easy it is to use the tables. Our calculations (including finding  $H_{75}$ ) were done using an old model HP-35 pocket calculator and the tables.

*Remark:* One must remember that the Bondurant theory assumes a linear increase in royalty rate and a geometric increase in production.

### Example 4.

When the royalty rate is constant ( $c_r = 0$ ) and production rate is constant ( $c_t = 0$ ), then the general formula reduces to the classic Hoskold formula. Suppose, for example, that  $T = 140,000,000$  tons production at a constant rate for 400 years until exhaustion of the coal reserves,  $R = \$0.50$  per ton constant royalty rate,  $i_s = 8\%$ ,  $i_p = 16\%$ ; then  $X = T \cdot R = \$70,000,000$  future yearly royalty income. We find

$$\begin{aligned} P_0 &= XH_{400} \\ &= 70,000,000 \left[ 0.16 + \frac{1.08}{1.08^{400} - 1} \right]^{-1} \\ &= 70,000,000 = \$437,500,000. \end{aligned}$$

### Example 5.

In Example 3, if we did not use the tables but knew Gould's limiting values (Theorems 1-7 above), we would find quickly that

$$\begin{aligned} A_\infty &= 1.16/(0.16)^2 = 45.3125; \\ B_\infty &= (0.07)(1.16)/(0.16)(0.09) = 5.63889; \\ E_\infty &= (45.3125)(0.07)(0.2756)/(0.09)^2 = 107.92207; \end{aligned}$$

whence present worth would not exceed  
 $33,000,000[6.24026 + (0.03)(45.31250)$   
 $+ 5.63889 + (0.03)(107.92207)] = \$543,714,174,$   
 which is 0.3% too high. For  $n$  much smaller than 75  
 the error would be considerably more.

### Literature Cited

- Baxter, Charles H. and Parks, Roland D. (1939): *Mine Examination and Valuation*, Second Edition. Houghton, Mich.
- Baxter, Charles H. and Parks, Roland D. (1949): *Examination and Valuation of Mineral Property*. Addison-Wesley Publ. Co., Cambridge, Mass.
- Davidson, Sidney (1970): *Handbook of Modern Accounting*. McGraw-Hill Book Co., New York, N.Y.
- Gould, H.W. (1975): Limiting and Asymptotic Behavior of the Bondurant-Hoskold Formulas for Valuation of Coal Mine Parcels for Equitable Tax Assessment, Preliminary Report. *Notices of Am. Math. Soc.* **22**, A-261, Abst. 720-99-5.
- Hardy, G.H., Littlewood, J.E. and Polya G. (1934): *Inequalities*. Cambridge Univ. Press.
- Hoskold, Henry D. (1877): *The Engineers Valuing Assistant*. Longmans, Green and Co., London.
- Hoskold, H. D. (1903): The Valuation of Mines of Definite Average Income. *Trans. Am. Inst. Mining Engrs.* **33**, 777-789.
- Hoskold, Henry D. (1905): *Engineer's Valuing Assistant*. Longmans, Green and Co., London.
- Korovkin, P.P. (1961): *Inequalities* (translated from original Russian by Halina Moss). Blaisdell Publ. Co., N.Y.
- LeVeque, W.J. (1965): *Topics in Number Theory*, Vol. I., p. 95. Addison-Wesley Publishing Co., Reading, Mass.
- Schlauch, William S. and Lang, Theodore (1942): *Mathematics of Business and Finance*. Ronald Press, New York, N.Y.



# Discrete Mechanics for Anisotropic Potentials

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**Abstract**—In previous work, a new type of numerical method for the solution of equations of motion was derived, denoted “discrete mechanics,” which has the unique property of conserving the additive constants of motion exactly. The discrete mechanics’ “forces” were obtained for the case of a general, separable potential with radial dependences. In certain applications, potentials occur which are expressed naturally in “anisotropic” form, involving the angles between vectors. In the present work, the formulas of discrete mechanics are extended to include potentials with anisotropy.

In previous work (LaBudde and Greenspan, 1974), an energy and angular momentum conserving numerical method—“discrete mechanics”—was derived for

the case of a separable, radially dependent potential  $\phi$ : i.e.,  $\phi$  is of the form

$$\phi(r_1, r_2, \dots, r_n) = \phi_1(r_1)\phi_2(r_2) \cdots \phi_n(r_n) \quad (1)$$

or is composed of a sum of terms of this type. Here  $\mathbf{r}_i$  is the coordinate vector of a particle  $i$  of a system of  $n$  particles, and  $r_i$  is its magnitude. For a complete description of the mechanics of the motion of the  $n$  particles subject to the potential  $\phi$ , as well as the basic formulas of “discrete mechanics,” see LaBudde and Greenspan (1976a and 1976b).

In simple terms, the problem is to determine the positions  $\mathbf{r}_1', \mathbf{r}_2', \dots, \mathbf{r}_n'$  and the velocities  $\mathbf{v}_1', \mathbf{v}_2', \dots, \mathbf{v}_n'$  of the  $n$  particles at time  $t' = t + \Delta t$ , given their positions  $\mathbf{r}_1, \mathbf{r}_2, \dots, \mathbf{r}_n$  and velocities  $\mathbf{v}_1, \mathbf{v}_2, \dots, \mathbf{v}_n$  at time  $t$ , in such a way that the energy  $E$  is conserved, where

$$E = T + \phi$$

The assumptions are that cartesian coordinates are used, so

$$T = \sum_{i=1}^n \frac{1}{2} m_i (\mathbf{v}_i \cdot \mathbf{v}_i)$$

where  $m_i$  is the mass of particle  $i$ , and the potential  $\phi$  is a sum of terms of the form of equation (1). The “discrete mechanics” solution is given by

$$\mathbf{r}_i' = \mathbf{r}_i + \mathbf{v}_i \Delta t + \mathbf{F}_i^* (\Delta t)^2 / (2m_i) \quad (2a)$$

$$\mathbf{v}_i' = \mathbf{v}_i + \mathbf{F}_i^* \Delta t / m_i \quad (2b)$$

which are implicit through the forces  $\mathbf{F}_i^*$  [cf. equation (5.71) of LaBudde and Greenspan (1974)]:

$$\mathbf{F}_i^* = - \frac{\Delta \tilde{\phi}_i}{\Delta r_i} \frac{\mathbf{r}_i' + \mathbf{r}_i}{r_i' + r_i} \quad (2)$$

The discrete mechanics forces  $\mathbf{F}_i^*$  are time-symmetrized finite-difference versions of the exact continuous forces. In equation (2c),

$$\Delta r_i = r_i' - r_i \quad (3)$$

and

$$\Delta \tilde{\phi}_1 = \frac{\phi_1' - \phi_1}{n} \sum_{\ell=0}^{n-1} \frac{1}{\binom{n-1}{\ell}} \sum_1^{(n-1)} \left( \prod_{s=1}^{\ell} \phi_{1s}' \right) \left( \prod_{s=\ell+1}^{n-1} \phi_{1s} \right) \quad (4)$$

In equation (4),

$$\phi_j' = \phi_j(r_j') \quad (5)$$

and the inner sum is over all combinations of the  $\phi_{1s}$  ( $i_s \neq i$ ) of which  $\ell$  are primed and  $n-1-\ell$  are unprimed. (The notation is such that null products with upper limits smaller than lower limits have value unity.) For example, if  $n=1$ , then

$$\Delta \tilde{\phi}_1 = \phi_1' - \phi_1 \quad (6)$$

For  $n=2$ ,

$$\Delta \tilde{\phi}_1 = \frac{\phi_1' - \phi_1}{2} [\phi_j' + \phi_j] \quad (j \neq i) \quad (7)$$

Finally, if  $n=3$ ,

$$\Delta \tilde{\phi}_1 = \frac{\phi_1' - \phi_1}{3} \left[ \phi_j' \phi_k' + \frac{1}{2} (\phi_j' \phi_k + \phi_j \phi_k') + \phi_j \phi_k \right] \quad (j \neq i, k \neq i, j) \quad (8)$$

Although many fundamental interactions are expressible in the separable form of equation (1), in certain problems "anisotropic" potentials arise which depend directly upon the angles between the radius vectors  $\mathbf{r}_1$ . Such potentials are usually obtained, for example, from the perturbation of a spherical distribution of charge which gives rise to the shapes of molecules (Hirschfelder et al., 1967). As an illustration, a typical case might have a potential term of the form

$$\phi(\mathbf{r}_1, \mathbf{r}_2) = \phi_1(\mathbf{r}_1) \phi_2(\mathbf{r}_2) \phi_{12}(\alpha_{12}) \quad (9)$$

where  $n=2$  and

$$\alpha_{12} = \mathbf{r}_1 \cdot \mathbf{r}_2 \quad (10)$$

The problem with  $\phi$  given by equation (9) is that its form does not correspond to that of equation (1). In order to construct the discrete mechanics "forces"  $\mathbf{F}_1^*$  via the formulas of LaBudde and Greenspan (1974),  $\phi$  would have to be expanded in terms of the variables  $\mathbf{r}_1$ ,  $\mathbf{r}_2$  and  $\mathbf{r}_3 = |\mathbf{r}_2 - \mathbf{r}_1|$ . The results must then be compounded term by term using equation (4). This process is very inefficient and time-consuming, since in general many terms in the expansion would be needed to accurately represent  $\phi$ . In order to avoid this complicated procedure, the discrete mechanics "forces" for  $\phi$  of the form of equation (9) will now be derived directly, without expansion.

First, in order to gain insight into the form of the  $\mathbf{F}_1^*$ , the classical forces  $\mathbf{F}_1$  will be examined. For  $\phi$  given by equation (9), the exact forces are

$$\mathbf{F}_1 = - \frac{\partial \phi}{\partial \mathbf{r}_1} \quad (11a)$$

$$= - \phi_2 \phi_{12} \frac{d\phi_1}{d\mathbf{r}_1} \frac{\mathbf{r}_1}{r_1} - \phi_1 \phi_2 \frac{d\phi_{12}}{d\alpha_{12}} \mathbf{r}_2 \quad (11b)$$

and

$$\mathbf{F}_2 = - \frac{\partial \phi}{\partial \mathbf{r}_2} \quad (12a)$$

$$= - \phi_1 \phi_2 \frac{d\phi_{12}}{d\alpha_{12}} \mathbf{r}_1 - \phi_1 \phi_{12} \frac{d\phi_2}{d\mathbf{r}_2} \frac{\mathbf{r}_2}{r_2} \quad (12b)$$

Because of the form of equations (11) and (12), the discrete mechanics "forces," in order to maintain consistency, may reasonably be expected to be composed also of two contributions, or:

$$\mathbf{F}_1^* = \mathbf{F}_{11}^* + \mathbf{F}_{12}^* \quad (13a)$$

$$\mathbf{F}_2^* = \mathbf{F}_{21}^* + \mathbf{F}_{22}^* \quad (13b)$$

where  $\mathbf{F}_{11}^*$  and  $\mathbf{F}_{12}^*$  are approximations to the two terms in equation (11b), and  $\mathbf{F}_{21}^*$  and  $\mathbf{F}_{22}^*$  are approximations to the two terms of equation (12b).

The forms of the  $\mathbf{F}_{ij}^*$  may be ascertained via consideration of the requirement of conservation of angular momentum. From equation (5.39) of LaBudde and Greenspan (1974), this condition requires

$$\frac{\mathbf{r}_1' + \mathbf{r}_1}{2} \times \mathbf{F}_1^* + \frac{\mathbf{r}_2' + \mathbf{r}_2}{2} \times \mathbf{F}_2^* = 0 \quad (14)$$

which must hold for all values of  $\mathbf{r}_1$ ,  $\mathbf{r}_2$ ,  $\mathbf{r}_1'$  and  $\mathbf{r}_2'$ . The general solution to equation (14) is given by

$$\mathbf{F}_1^* = \mathbf{F}_{11}^*(\mathbf{r}_1' + \mathbf{r}_1) + \mathbf{F}_{12}^*(\mathbf{r}_2' + \mathbf{r}_2) \quad (15a)$$

$$\mathbf{F}_2^* = \mathbf{F}_{21}^*(\mathbf{r}_1' + \mathbf{r}_1) + \mathbf{F}_{22}^*(\mathbf{r}_2' + \mathbf{r}_2) \quad (15b)$$

with  $\mathbf{F}_{12}^* = \mathbf{F}_{21}^*$  and the  $\mathbf{F}_{ij}^*$  otherwise unrestricted. By comparison of equations (13) and (15), satisfactory choices for the  $\mathbf{F}_{ij}^*$  are

$$\mathbf{F}_{11}^* = \mathbf{F}_{11}^*(\mathbf{r}_1' + \mathbf{r}_1) \quad (16a)$$

$$\mathbf{F}_{12}^* = \mathbf{F}_{12}^*(\mathbf{r}_2' + \mathbf{r}_2) \quad (16b)$$

$$\mathbf{F}_{21}^* = \mathbf{F}_{21}^*(\mathbf{r}_1' + \mathbf{r}_1) \quad (16c)$$

$$\mathbf{F}_{22}^* = \mathbf{F}_{22}^*(\mathbf{r}_2' + \mathbf{r}_2) \quad (16d)$$

The symmetric matrix of coefficients  $\mathbf{F}_{ij}^*$  remains to be determined. From equation (5.24b) of LaBudde and Greenspan (1974), conservation of energy requires

$$\mathbf{F}_1^* \cdot (\mathbf{r}_1' - \mathbf{r}_1) + \mathbf{F}_2^* \cdot (\mathbf{r}_2' - \mathbf{r}_2) = \phi_1 \phi_2 \phi_{12} - \phi_1' \phi_2' \phi_{12}' \quad (17)$$

Substitution of equation (15) into equation (17) yields

$$\Delta T_1 + \Delta T_2 + \Delta T_{12} = \phi_1 \phi_2 \phi_{12} - \phi_1' \phi_2' \phi_{12}' \quad (18)$$

where

$$\Delta T_1 = \mathbf{F}_{11}^* [(\mathbf{r}_1')^2 - \mathbf{r}_1^2] \quad (19a)$$

$$\Delta T_2 = \mathbf{F}_{22}^* [(\mathbf{r}_2')^2 - \mathbf{r}_2^2] \quad (19b)$$

$$\Delta T_{12} = 2\mathbf{F}_{12}^* (\alpha_{12}' - \alpha_{12}) \quad (19c)$$



Now, equation (18) is identical in form to equation (5.50) of LaBudde and Greenspan (1974) for  $n = 3$  (i.e., *three* particles) if a pseudoradius  $r_3 = \alpha_{12}$  is defined. Therefore, the solution obtained by LaBudde and Greenspan (1974) for equation (5.50) also suffices for equation (17); if  $\alpha_{12}$  is substituted for  $r_3$ :

$$\Delta T_1 = -\Delta \tilde{\phi}_1 \quad (20a)$$

$$\Delta T_2 = -\Delta \tilde{\phi}_2 \quad (20b)$$

$$\Delta T_{12} = -\Delta \tilde{\phi}_{12} \quad (20c)$$

where the  $\Delta \tilde{\phi}$  are given by equation (8), i.e.,

$$\Delta \tilde{\phi}_1 = \frac{1}{3} \left[ \phi_2' \phi_{12}' + \frac{1}{2} (\phi_2' \phi_{12} + \phi_2 \phi_{12}') \right. \\ \left. + \phi_2 \phi_{12} \right] (\phi_1' - \phi_1) \quad (21a)$$

$$\Delta \tilde{\phi}_2 = \frac{1}{3} \left[ \phi_1' \phi_{12}' + \frac{1}{2} (\phi_1' \phi_{12} + \phi_1 \phi_{12}') \right. \\ \left. + \phi_1 \phi_{12} \right] (\phi_2' - \phi_2) \quad (21b)$$

$$\Delta \tilde{\phi}_{12} = \frac{1}{3} \left[ \phi_1' \phi_2' + \frac{1}{2} (\phi_1' \phi_2 + \phi_1 \phi_2') \right. \\ \left. + \phi_1 \phi_2 \right] (\phi_{12}' - \phi_{12}) \quad (21c)$$

Substituting equations (20) and (21) into equations (19) then gives the discrete mechanics "forces" corresponding to  $\phi$  of the form of equation (9):

$$\mathbf{F}_1^* = -\frac{\Delta \tilde{\phi}_1}{\Delta r_1} \frac{\mathbf{r}_1' + \mathbf{r}_1}{r_1' + r_1} - \frac{\Delta \tilde{\phi}_{12}}{\Delta \alpha_{12}} \frac{\mathbf{r}_2' + \mathbf{r}_2}{2} \quad (22a)$$

$$\mathbf{F}_2^* = -\frac{\Delta \tilde{\phi}_{12}}{\Delta \alpha_{12}} \frac{\mathbf{r}_1' + \mathbf{r}_1}{2} - \frac{\Delta \tilde{\phi}_2}{\Delta r_2} \frac{\mathbf{r}_2' + \mathbf{r}_2}{r_2' + r_2} \quad (22b)$$

where  $\Delta \alpha_{12} = \alpha_{12}' - \alpha_{12}$ . In the limit  $\Delta t \rightarrow 0$ , equations (22) of course reduce to equations (11) and (12).

As a physical example of the use of equations (22), consider the case of the interaction of an atom A with a diatomic molecule BC. Let  $\mathbf{R}$  denote the vector from the center-of-mass of BC to A, and  $\mathbf{r}$  the vector from B to C. Standard potential forms for this interaction involve anisotropic terms of the type (Hirschfelder et al., 1967):

$$\phi(\mathbf{R}, \mathbf{r}, \alpha) = -\frac{\gamma \alpha}{R^7 r} \quad (23)$$

where  $\alpha = \mathbf{R} \cdot \mathbf{r}$ , and  $\gamma$  is a constant. Since for these coordinates the kinetic energy  $T$  is diagonal in  $\mathbf{R}$  and  $\mathbf{r}$ ,

$$T = \frac{1}{2} \mu_{A,BC} \left| \frac{d\mathbf{R}}{dt} \right|^2 + \frac{1}{2} \mu_{BC} \left| \frac{d\mathbf{r}}{dt} \right|^2 \quad (24)$$

the equations of motion are identical to these of two particles, one with position vector  $\mathbf{R}$ , and the other with position vector  $\mathbf{r}$ . The respective "masses" of the particles are

$$\mu_{A,BC} = \frac{m_A(m_B + m_C)}{m_A + m_B + m_C} \quad (25)$$

and

$$\mu_{BC} = \frac{m_B m_C}{m_B + m_C} \quad (26)$$

where  $m_A$ ,  $m_B$ , and  $m_C$  are the masses of A, B, and C, respectively.

The potential  $\phi$  is now seen to be of the form of equation (9) with

$$\phi_R(\mathbf{R}) = -\frac{\gamma}{R^7} \quad (27a)$$

$$\phi_r(\mathbf{r}) = \frac{1}{r} \quad (27b)$$

$$\phi_\alpha(\alpha) = \alpha \quad (27c)$$

From equations (22), the forces  $\mathbf{F}_R^*$  and  $\mathbf{F}_r^*$  corresponding to  $\phi$  of equation (23) are given by

$$\mathbf{F}_R^* = -\frac{\Delta \tilde{\phi}_R}{R' - R} \frac{\mathbf{R}' + \mathbf{R}}{R' + R} - \frac{\Delta \tilde{\phi}_\alpha}{\alpha' - \alpha} \frac{\mathbf{r}' + \mathbf{r}}{2} \quad (28a)$$

$$\mathbf{F}_r^* = -\frac{\Delta \tilde{\phi}_\alpha}{\alpha' - \alpha} \frac{\mathbf{R}' + \mathbf{R}}{2} - \frac{\Delta \tilde{\phi}_r}{r' - r} \frac{\mathbf{r}' + \mathbf{r}}{r' + r} \quad (28b)$$

where

$$\Delta \tilde{\phi}_R = \frac{\gamma}{3} \left[ \frac{\alpha'}{r'} + \frac{\alpha}{2r'} + \frac{\alpha'}{2r} + \frac{\alpha}{r} \right] \\ \cdot \left( \frac{1}{R^7} - \frac{1}{(R')^7} \right) \quad (29a)$$

$$\Delta \tilde{\phi}_r = \frac{\gamma}{3} \left[ \frac{\alpha'}{(R')^7} + \frac{\alpha}{2(R')^7} + \frac{\alpha'}{2R^7} + \frac{\alpha}{R^7} \right] \\ \cdot \left( \frac{1}{r} - \frac{1}{r'} \right) \quad (29b)$$

$$\Delta \tilde{\phi}_\alpha = \frac{\gamma}{3} \left[ \frac{1}{(R')^7 r'} + \frac{1}{2(R')^7 r} + \frac{1}{2R^7 r'} + \frac{1}{R^7 r} \right] \\ \cdot (\alpha - \alpha') \quad (29c)$$

Equations (28) are all that is needed, together with the formulas of LaBudde and Greenspan (1974), to numerically determine the conservative motion of the three particles A, B, and C.

In summary, for the case of a potential  $\phi$  of the form given by equation (9), the discrete mechanics forces are obtained by considering the  $r_1$  and  $r_2$  terms in the energy and angular momentum simultaneously. The resulting implicit expressions for  $\mathbf{F}_1^*$  and  $\mathbf{F}_2^*$  are given by equations (22) and (21). The  $\mathbf{F}_1^*$  for the general case of an  $n$ -body system with a more complicated form of  $\phi$  may be obtained in an analogous way by treating the  $\mathbf{r}_i \cdot \mathbf{r}_j$  the same as radial dependences, with vector directions determined as above in equations (15).

As remarked in LaBudde and Greenspan, (1974),

the same discrete mechanics solution holds for the case of  $\phi$  dependent upon the distances  $r_{ij}$  *between* particles, if the  $r_{ij}$  are used in place of  $r_i$  and  $n$  is replaced by  $N = n(n - 1)/2$ .

### Literature Cited

Hirschfelder, J. O., Curtiss, C. F. and Bird, R. B. (1967): *Molecular Theory of Gases and Liquids*. Wiley, New York, N.Y., Chapters 12-14.

LaBudde, R. A. and Greenspan, D. (1974): Discrete Mechanics—a General Treatment. *J. Computational Phys.* **15**, 134.

LaBudde, R. A. and Greenspan, D. (1976a): Energy and Angular Momentum Conserving Methods of Arbitrary Order for the Numerical Solution of Equations of Motion. I. Motion of a Single Particle. *Numerische Math.* **25**, 323-346.

LaBudde, R. A. and Greenspan, D. (1976b): Energy and Angular Momentum Conserving Methods of Arbitrary Order for the Numerical Solution of Equations of Motion II. Motion of a System of Particles. *Numerische Math.* **26**, 1-16.

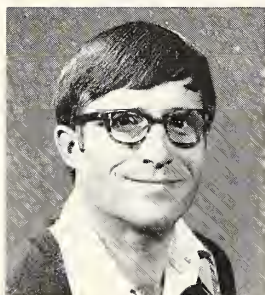


# Field Work in Virginia's Secondary School Earth Science Classes

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Results from surveys regarding secondary school earth science have shown that teachers have not conducted many field trips. Other than reference to a few hindrances the reports have not explained their limited use. In his doctoral dissertation (New York Univ., 1968), Glenn called for a comprehensive study of outdoor school experiences and an examination of the extent to which field trips were used. This paper reports an attempt to carry out Glenn's suggestion by studying, in detail, the status of earth science field work in Virginia.

Exline (doctoral dissertation, Univ. of Maryland, 1973), in a general survey of earth science in Virginia, collected data by regional study areas to permit comparison of various regions within the state. The same regions were used in this study. A list of counties in each region can be found in the *State Superintendent's Annual Report (1973-74)*.

## PROCEDURES AND FINDINGS

In 1975 questionnaires were sent to teachers who had at least 50 percent of their assignment in earth science. Each teacher was asked to report the time devoted to various field practices for a typical class during the school year. Materials were sent to 335 teachers, and 207 (62%) usable questionnaires were returned.

Findings showed that over 60 percent of the 1974-75 Virginia teachers conducted at least 4 trips and only 17 percent failed to take any. Results of Exline's study indicated that only 20 percent of the teachers conducted 3 or more trips and 29 percent took none. A Wisconsin survey by Wall and Qutub (1972) found that 43 percent of the respondents did not conduct field trips. In Colorado, Bybee (1971) found that only 16 of 115 teachers took 4 or more earth science trips during the year.

These figures indicated increased field work involvement by the Virginia teachers, but only 12 percent of the teachers did the 27 hours of work which were required to classify as highly active. The percent of inactive (no field work) and moderately active programs (0-27 hours) were also identified. Region VI (Roanoke area) had the highest percent (25) of highly active field programs and Region I (Richmond area) had the lowest percent (4.5). All regions had at least 60 percent of the teachers classified as moderately active. Only Region II (Norfolk area), Region V (Charlottesville-Lynchburg area) and Region VII (Southwest Virginia) had more than 20 percent completely inactive teachers. Although some regions appeared to be doing more field work than others, differences were not statistically significant.

The mean number of total field sessions per teacher in 1974-75 for typical classes in Virginia was 8.3, and the mean number of total instructional hours spent with field activities was 13.4. More than 50 percent of the field instruction time occurred on-grounds, 35 percent off-grounds, and 15 percent near-grounds. The same pattern was found in each region.

Teachers estimated the actual amount of time devoted to field activities and indicated the amount of time they would have preferred. Results showed that they wanted to make significant increases in the number of field sessions (Table I), the number of field hours (Table II), and various types of field practices. Increases were desired in all three locational categories.

Kinds of field work for which teachers showed the greatest desire for increasing time were practical field problems, field projects, research trips, and collecting for classifying activities. Another group of practices studied were procedures for planning and conducting field activities. Those which received the greatest preference for increasing time were (1) planning activities for specific concepts suited to outdoor study; (2) selecting activities that are related directly to in-class instruction; (3) providing pretrip planning; (4) providing follow-up; (5) visiting sites prior to the trip; and (6) preparing field guides.

Teachers perceived many hindrances to the development of good field programs. The main hindrances were (1) lack of planning time; (2) lack of resource people; (3) failure of the school to assume trip risk; (4) lack of a method for covering classes; (5) restrictions caused by school regulations; (6) lack of admin-

TABLE 1

*Mean Number of Actual and Preferred Field Work Sessions and t Values for Differences in These Means for Virginia in 1974-75*

Field Session Categories	Actual		Preferred		t-Value
	Mean	S D	Mean	S D	
On-grounds	5.5	6.1	12.1	12.3	10.2*
Near-grounds	1.0	2.8	4.3	6.7	8.6*
Off-grounds	1.8	3.2	6.0	7.2	10.5*
Total Sessions	8.3	8.9	22.3	20.7	12.4*

\* Significant at the .001 level

istrative support; (7) lack of funding; and (8) limited transportation.

Major recommendations for improvement were that (1) state agencies compile materials and specimens for field sites; (2) in-service courses be offered by state and local school agencies that will help develop field techniques; and (3) school leadership place more emphasis on field work.

Results of another aspect of the study demonstrated a statistically significant relationship between time spent in field activities with classes and the teacher's interest in doing personal field work. Characteristics that did not show a significant relationship were earth science experience, educational background, earth science program, available transportation, and the school environment.

Teachers in this study indicated they have increased the amount of field work and that they would like to do even more. Most of the activities were on the school grounds, and teachers preferred to con-

TABLE 2

*Mean Number of Actual and Preferred Hours of Field Instruction and t Values for Differences in These Means for Virginia in 1974-75*

Categories	Actual		Preferred		t-Value
	Mean	S D	Mean	S D	
On-grounds	7.1	8.9	15.4	17.0	10.2*
Near-grounds	1.5	4.3	5.2	8.1	9.1*
Off-grounds	4.8	6.7	14.0	11.9	13.5*
Total Hours	13.4	13.8	34.7	27.7	15.1*

\* Significant at the .001 level

tinue this practice. Additional training opportunities were recommended as one way to increase the amount of field instruction. Teachers suggested that the training be provided by state and local school agencies through inservice courses which aid in the location and proper use of field sites. School officials should be aware that prospective teachers who have become involved in *personal* field work might provide more field activities for their classes.

### Literature Cited

- Bybee, Rodger W. (1971): The Status of Earth Science Education in the Secondary Schools of Colorado. *Colo. J. Ed. Res.* **10**, 4, 20.
- State Board of Education (1974): Annual Report of the Superintendent of Public Instruction of the Commonwealth of Virginia School Year 1973-74, pp. 14-15. Richmond, Virginia.
- Wall, Charles A. and Musa Y. Qutub (1972): Earth Science in Wisconsin Secondary Schools. *J. Geol. Ed.* **20**, 2, 84-85.



## NEWS, NOTES AND ANNOUNCEMENTS

### VIRGINIA CENTER FOR COAL & ENERGY RESEARCH

The Board of Visitors of VPI & SU announced the formal establishment of the Virginia Center for Coal and Energy Research at the State University. The center, established by the Virginia Legislature to perform research, educational and archival functions in the areas of coal and energy, is to be located in Holden Hall at VPI & SU under the executive directorship of Dr. Walter R. Hibbard, Jr. Dr. Hibbard, a VAS member and a former Director of the United States Bureau of Mines holds the rank of University Distinguished Professor of Engineering. Prior to his arrival at the University, Dr. Hibbard held research positions at Owens-Corning, General Electric, and the Federal Energy Office.

In outlining the center's tasks, Dr. Hibbard pointed out his office's role in helping acquire and coordinate multi-institutional and/or multi-departmental research grants or contracts from appropriate organizations. In a meeting with Drs. Michael Bishara (Southwest Virginia Community College), Herbert Funsten (College of William & Mary), John Gibson (University of Virginia), Gordon Melson (Virginia Commonwealth University) and A. Sidney Roberts (Old Dominion University), he encouraged them to stimulate submittal to his office of worthy proposals which need funding.

In carrying out his appointed task, Dr. Hibbard will interact with an 18-person advisory committee appointed by the Board of Visitors at VPI & SU. In addition to the above-mentioned representatives of Virginia educational institutions, the committee will include Messrs. J. Robert Bray (Virginia Port Authority), Samuel C. Brown, Jr. (VEPCO), Donald W. Jones (Pittston Coal Group), Jack W. Kepner (Appalachian Power Companies), Mark Kilduff (Virginia Division of Industrial Development), a representative of Virginia Energy Office, Frank Linkous (Virginia Division of Mines), Peter G. Marozzi, III (United Coal Companies), Ray W. Marshall (United Mine Workers of America), J. R. Tomlinson, (Virginia Iron, Coal & Coke), and Drs. James Calver, (Virginia Division of Mineral Resources) and Noel Taylor, (City of Roanoke). Mr. John Fishwick (Norfolk and Western Railroad) will act as chairman of the advisory committee.

Dr. Hibbard indicated his willingness to assist interested Virginia researchers in the formulation of proposals relating to any of the major energy areas. He can be contacted at VPI & SU (703-951-6473).

### SYMPOSIA PLANNED FOR 56TH ANNUAL VAS MEETING

The *Environmental Sciences Section* has planned a symposium on the *Applications of Science in Coastal Resources Management* to be held at 1:30 to 4:00 p.m. on Thursday, May 11, 1978. Topics included in the symposium are characteristics and effects of non-point pollution, erosion effects of estuarine waters, and evaluation and classification of tidal wetlands. The speakers at the symposium include Maurice Rowe, Commonwealth's secretary of commerce and resources; William J. Hargis, Jr., VIMS' director; Lee Hill of soil and water conservation commission; Robert Byrne, Bruce Neilson and Gene Silberhorn of VIMS; and Sandra Batie and Clifford Randle of VPI & SU.

The *Psychology Section's* symposium has the title *Psychology in Virginia*. Chaired by professor emeritus William M. Hinton (Washington and Lee University), the symposium will cover the topics: history of psychology section (Frank Finger, U.VA), undergraduate programs (Frank Murray, R-MWC), masters degree programs (Paul Woods, Hollins Coll.), doctoral programs (James Deese, U.VA), VA Psychiatric Association perspectives (Robert Tipton, VPA), VA Board of Psychologists Examiners perspectives (Richard Abiden, VBPE) and a perspective on psychology in Virginia (B. von Haller Gilmer).

### THIRD PHILIP MORRIS SCIENCE SYMPOSIUM

Structure and Biochemistry of natural biological systems will be the theme of the third Philip Morris Science Symposium to be held on November 9, 1978. Chaired by Ian Scott (Texas A & M University), the symposium will cover the following topics: participation of cell surface polymers in interactions between plants and microorganisms (Peter Albersheim, Univ. of Colorado at Boulder); biogenesis of natural polymer systems with special reference to cellulose assembly and deposition (R. Malcolm Brown, Jr., UNC at Chapel Hill); oxygen functions in living enzyme systems (Britton Chance, Univ. of Pennsylvania); spatial configuration of natural and synthetic macromolecules (Paul J. Flory, Stanford Univ.); regulation and control in enzymatic and behavioral systems (Daniel E. Koshland, Jr.); and structure and mechanical properties of natural polymer systems (Robert H. Marchessault, Univ. of Montreal). Inquiries for additional information may be addressed to Karol G. Sharp, Philip Morris Research Center, P.O. Box 26583, Richmond, VA 23261.

### VIRGINIA FLORA SOCIETY

The *first* part of the Virginia Flora is now available. Compiled by A. M. Harvill, Jr., C. E. Stevens and D. M. E. Ware, it includes contributions by E. Berkeley, D. C. Bliss, and P. M. Mazzeo. The first floral atlas for Virginia ever published, it is a major contribution to the floristic knowledge of the Old Dominion.

The Atlas provides a general introduction, traces history of botanical exploration from the Colonial times to the present, and discusses physiography and geological history, climate and soils, vegetational history. It also includes distribution dot-maps for the various specific and occasionally subspecific taxa representing the ferns and their allies (Pteridophytes), conebearing plants and their relatives (Gymnosperms), and the three-parted flowering plants (Monocotyledons).

The Atlas may be purchased for \$3.85 from Virginia Botanical Associates, Route 6, Box 130, Farmville, Virginia 23091.

### SUMMARY OF COUNCIL ACTIONS TAKEN AT ITS MEETING HELD

MARCH 4, 1978

*Not Available*

*Editor's Note:* For lack of timely inputs regarding features from the Academy officers, the Winter, 1977 and Spring, 1978 issues were considerably delayed. It is uncertain at this time when the summer, 1978 and the succeeding issues shall be ready for distribution. In case of delay, send inquiries to Dr. Dale V. Ulrich, President, VAS, c/o Bridgewater College, Bridgewater, VA 22812.

# GENERAL NOTICE TO CONTRIBUTORS

The Virginia Journal of Science welcomes for consideration original articles in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

Articles (other than abstracts, correspondence and comments, and news and notes) should be sent to the Editor, Dr. Kuldip P. Chopra, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA. 23508. Manuscripts dealing with science and society, history of science and technology, correspondence, and news and notes should be addressed to the Associate Editor, Dr. Michael N. Bishara, Engineering Division, Southwest Community College, Richlands, VA. 24641. Short notes (not exceeding eight double-spaced typed pages, 2500 words or equivalent including illustrations) may be sent to the Editor or one of the members of the Editorial Board. Proofs, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

The original and **three** copies of each manuscript and small photo copies of large drawings are required. All articles should be typewritten, double-spaced throughout, on one side of good bond paper ( $8\frac{1}{2} \times 11$  inches). Margins should be not less than  $1\frac{1}{4}$  inches on any border. Each manuscript should be complete and final when submitted, and should include the following:

1. Title, author's name and affiliation, and dateline appearing on a separate page.
2. Author's glossy photograph and brief (50 word) professional biography including name, position, degrees received (when and where), awards and honors, and principal research interests.
3. Abstract. An abstract summarizing the text, particularly the results and conclusions, is required at the beginning of each article. This should appear on a separate page.
4. Text. The text should be divided into sections and subsections (if necessary), each with a separate heading. Section headings should be typed on a separate line and centered. Subsections should be set into the text and underlined. Sections and subsections should **not** be in capitals.
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6. References. Literature cited in the text should follow the name- and year-format: Birkhoff and Zarantonello (1957), or (Simpson and Dennis, 1974). List of references, in the section so titled, should be arranged alphabetically on a separate page. Abbreviations for journal articles should conform to the List of Periodicals in the Chemical Abstracts Service Source Index, the American Institute of Physics Style Manual or the Bibliographic Guide for Editors and Writers.

Each reference should be complete and in the following form: author(s), year within parentheses, title of article, title of journal (abbreviated and underlined or

typed in script), volume number (underline with wavy line), and pages. For a book: author(s), year, title of book (underlined or typed in script), page, publisher and city of publication. Examples:

Birkhoff, G. and Zarantonello, E. H. (1957): Jets, Wakes and Cavities, pp. 280-293. Academic Press, New York.

Chopra, K. P. (1961): Interactions of Rapidly Moving Objects in Terrestrial Atmosphere. *Rev. Mod. Phys.* **33**, 153-172.

Simpson, J. and Dennis, A. S. (1974): Cumulus clouds and their Modification. In *Weather Modification* (W. N. Hess, ed.), Chap. 6, pp. 229-280, Wiley, New York.

**References to project or company reports, technical memoranda and personal communications are not permissible**, except as footnotes under exceptional situations. Footnotes in the text should be numbered serially throughout a manuscript.

7. Illustrations. Glossy prints are preferred to oversized original drawings. The lettering on the latter should be such that the smallest character after reduction is about 1.5 mm high. Each figure should be mentioned specifically in the text. Figure number and legend will be set in type and **must not** be part of the drawing. All legends should be typed together, and figures identified by author's name and figure number in pencil on the back.

8. Tables. Each table should be numbered in Roman numerals, carry a title which is complete and intelligible, should have clear and concise column headings and should be typed on a separate page. Indicate units where needed. Footnotes should be designed by a superior lower case letter (a, b, c, etc.) and should begin anew for each table.

9. Mathematical Symbols and Formulas. Formulas should be composed carefully for utmost clarity and economy. Equations should be identified with numbers within parenthesis at the right-hand margin. The word equation(s) in the text should be abbreviated Eq(s). Radical sign should be avoided; to indicate roots, use a fractional exponent. For fractions, use solidus (/), the negative exponent or the division sign. Examples:  $a/b^{1/2}$ , or  $ab^{-1/2}$ , or  $a \div b^{1/2}$ . Avoid double-line fractions, double subscripts or superscripts, and indicate vectors or matrices by placing a wavy line under the symbol. When the exponent  $e$  is modified by a complicated exponent, use the symbol  $\exp$ . Use of International System of Units is preferred. Explain unusual symbols with marginal notes in pencil.

Please note that the above format is a change from the past practice in the Journal. Manuscripts not conforming to the above guidelines shall be returned. There are no page charges at the present time. However, the VJS reserves the right to make page charges for very long manuscripts, and to bill the authors at cost for unusually complicated illustrative material, extraordinary alterations in the text in proof, or when major retying of the manuscript is warranted.





# VIRGINIA JOURNAL OF SCIENCE

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All correspondence, remittances, and orders relating to advertising, subscriptions, missing issues, and other business affairs should be addressed to Auzville Jackson, Jr., Business Manager, Virginia Journal of Science, c/o Robertshaw Controls Company, P.O. Box 26544, Richmond, VA 23261. Changes of address, including both new and old zip codes, should be sent promptly to Blanton M. Bruner, Executive Secretary-Treasurer, Virginia Academy of Science, P. O. Box 8454, Richmond, VA 23226.

# VIRGINIA JOURNAL OF SCIENCE

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# Virginia Academy of Science Fifty-Sixth Annual Meeting, Blacksburg May 9-12, 1978

## Summary of Academy Conference and Academy Assembly and Notes From Council Meetings

*Based on inputs from Ken Bovard, the Academy Secretary, and others.*

May 10, 1978

The Council of the Virginia Academy of Science met on Wednesday, May 10, 1978 in Conference Room D, Donaldson Brown Continuing Education Center at VPI & SU, Blacksburg, Virginia. R. A. Lowry called the meeting to order at 2:05 p.m. with 26 members of the Council present. In attendance were L. D. Abbott, R. G. Bass, M.N. Bishara, K. P. Bovard, B. M. Bruner, A. W. Burke, Jr., K. P. Chopra, E. M. Cliff, V. C. Ellett, M. R. Escobar, G. H. Johnson, J. L. Hess, F. B. Leftwich, K. R. Lawless, R. A. Lowry, P. M. Mazzeo, W. B. Newbolt, R. A. Patterson, W. A. Powell, V.B. Remsburg, G. R. Taylor, E. Thompson, D. V. Ulrich, W. R. West, Jr., J. H. Wise, J. E. White, E. L. Wisman, and R. C. Berry (retired Executive-Secretary).

### President's Report

President Lowry noted that he had mailed letters to all award recipients. He requested section chairpersons to (1) secure letters for nomination of the fellows, (2) encourage membership drives in their sections, and (3) announce the policy on awards and prizes by the sections. He also reported that he had sent a letter to the Governor concerning the Academy's Science Advisory Committee.

### President-Elect's Report

Dale V. Ulrich reported that the program for the 56th Annual Meeting was prepared in cooperation with the Section Secretaries. An innovation in the 1978 program was the opportunity for members to present scientific papers in the poster sessions. He also noted that committee appointments were progressing, though, several assignments needed to be made. He invited suggestions.

### Executive-Secretary's Report

Blanton Bruner reported that the Auditor's Report for the year 1977 has been completed and sent to the Executive Committee.

### Report of Chairperson, Local Arrangements Committee

Dr. Cochran, Chairperson, reported that, while all committee plans were moving smoothly, the response to banquet tickets was weak and an announcement

should be made at the Council meeting to encourage attendance. President Lowry commended the Local Arrangements Committee for its excellent organizational work.

### Report From the Executive Committee

The President reported that the Psychology Section has requested a resolution recognizing the work of Dr. Frank F. Gilgard. Arthur Burke made the motion that Council's action was not necessary because a resolution made by a section would preserve the autonomy of the section. The motion was seconded and approved by voice vote. It was recommended that the resolution be sent to the Journal for publication. (*Editor's Note:* The editor has not received the Psychology Section's resolution).

The President announced that Auzville Jackson, Jr. has resigned as business manager of the Virginia Journal of Science, to be effective as of October 1, 1978 or as soon as a replacement can be secured. Discussion of the role of advertising and business manager for the Journal indicated that the role of the business manager must be the first concern of the Publication Committee. A review of the needs for the Journal was discussed with the suggestion that the Publication Committee present a formal report at the Council Meeting on Friday, May 12.

### Report of The Editor, Virginia Journal of Science

Dr. Kuldeep P. Chopra, Editor, reported that he has processed 42 papers of which 19 have been published or are in press, and 20 have been returned to authors for revision or nonacceptance. He said that the Winter 1977 issue has been printed and should be mailed during the next week, and the Spring 1978 issue is almost ready. He expressed his frustrations over delays in publication due to (1) very limited and unreliable clerical (part-time work-study student) assistance, (2) failure of contributors, particularly the academy officers, to make their contributions of editorials, news and features to meet publication schedule, and (3) a very small flow of good articles to the Editor's office. He expressed his concern over the warnings from the U.S. Postal Service about the need to keep the Journal on schedule, and over the recent resignation of the Business Manager. He expressed hope that the revitalized role of the Section Editors will alleviate the problem of a contribution shortage and lessen his editorial work. A meeting of the Sec-



tion Editors and the Editorial Board has been called for May 12. He solicited support and advice of the Council Members in strengthening the Journal.

### **Report of the Director, Visiting Scientist's Program**

Dr. Gerald K. Taylor, Director of the Visiting Scientist Program, reported that during the 1977-78 academic year a total of 976 topics were offered to students in Virginia high schools and science clubs. A total of 612 scientists and educators from 31 universities and colleges in Virginia spoke to a combined audience of 3134 students. Several fine expressions of appreciation for the programs have been received this year.

### **Reports of Standing Committees**

#### *Publications Committee*

Chairperson Jack H. Wise reported that the Section Editors have been advised of the plan by Council to circulate a questionnaire to all members requesting opinions in regard to the continuation of the Journal, its format and quality, advertising, page charges, dues, etc. The Section Editors have been asked to urge members of their respective sections to submit papers for publication to the Editor.

#### *Awards Committee*

Lynn D. Abbott, Chairperson, reported that Blanton M. Bruner, Arthur W. Burke, Jr., Herbert McKennis, Jr., W. Allan Powell, and Stanley Ragone were elected Fellows at the Council meeting held in March. Beverly Orndorff, science writer for the Richmond Times Dispatch, was elected as an Honorary Life Member. Rodney C. Berry was selected for the Ivey F. Lewis Distinguished Service Award for 1978. Authorization to establish an award in the name of Jesse W. Beams, Distinguished Scientist and President of the Academy (1947-48) was requested. Nominations for Fellows, Ivey F. Lewis and Honorary Life Member Awards were requested to be sent to the Executive Secretary before June 1.

#### *Fund Raising Committee*

President Lowry reported for Chairperson Sam Gillespie that the membership has contributed over \$900 towards support of research, and that the prospective industrial and private contributors have been contacted.

#### *Virginia Junior Academy of Science Committee*

J. L. Hess reported that 435 students, 90 teacher-sponsor-chaperons and 50 high school science clubs were registered at this year's annual meeting. From the 365 submitted papers, 226 were selected for presentation at the meeting. The following awards were presented: The E.C.L. Miller award to the Pulaski High School Science Club for the third successive year; Distinguished Service award to J. L. Hess, retiring director; VAS Science Teacher award to Joyce Peterson; and the Philip Morris Award to Elrica Graham and John Joseph of Pulaski. The Proceedings Volume of this year's meeting is dedicated to Mrs.

Vera Remsburg. The Junior Academy raised \$1680 in contributions from business and individual connections. Reynolds Metals of Richmond returned to sponsor the Environmental Sciences Section.

#### *Membership*

W. R. West reported the availability of a new printing of VAS flyers and membership applications. In a review of registration records for the current attendance at the annual meeting, it appeared that nearly 400 persons were not members of VAS. A special effort was made to contact some of the people to solicit new memberships.

#### *Nominating Committee*

E. L. Wisman reported anticipation of an orderly election of officers. President Lowry requested that the election be the first item of business at the Academy Conference.

#### *Research Committee*

R. A. Patterson reported that 12 research grant proposals were received; 5 of these were approved and recommended for funding; 4 were denied, and 3 are awaiting review by the committee. He announced that eight papers were submitted in competition for the J. Shelton Horsley Research Award. These were sent to the West Virginia University Sigma Xi Chapter for review and evaluation. The winning paper is "Fatigue Damage: Stiffness/Strength Comparison for Composite Materials" by T. K. O'Brien and K. L. Reifsnider of the Engineering Science and Mechanics Department at VPI & SU. Distribution of press releases concerning research grants and continuation of J. Shelton Horsley Research Award publicity was suggested. A motion to replace \$1000 to the general fund for the use of the Research Fund during the calendar year was made, seconded, and carried. The Trust Committee will transfer the funds.

#### *Trust Committee*

Stanley Ragone reported that the Academy Trust Funds were handled by First and Merchants Bank of Richmond under an agreement dated November 23, 1976. As of February 22, 1978, the funds' status is estimated 1978 cash income from the trust, \$2,953.; market value, \$43,571. Performance of the account seems to be in line with performance of the market in general. The VAS added \$877 to the Trust Fund early in 1978 through the Executive Secretary's office.

#### *Virginia Flora Committee*

Peter M. Mazzeo reported that Martha K. Roane was named the new Chairperson of the committee, and Michael Hill was appointed to the committee. The Flora Committee has a balance of \$341.30 in funds, plus the 1977 appropriation of \$300.00, available for research. The disbursement of these funds will be discussed at the November meeting of the committee.

## Reports of Ad Hoc Committees

### *Archives*

Boyd Harshbarger reported the literature of the VAS was classified by subject and author, with much of this material in files on the fourth floor, Hutcheson Hall, VPI & SU. Loose material, including correspondence, reprints, minutes and early Academy history are in carrels in the original Agriculture Library. Two projects are planned: (1) copies of papers which won the Jefferson and Horsley Awards as well as other historical papers should become part of the archives, and (2) papers and other materials on the Dismal Swamp should be culminated. Academy members were urged to contact the Archivist (Boyd Harshbarger), VAS, c/o Statistics Department, VPI & SU, Blacksburg, VA 24061.

### *Science Advisory*

Ertle Thompson reported on the activities of the preceeding year which included (1) acceptance of the concept of the Science Advisory Committee by the Academy Conference held May 12, 1977 at Petersburg; (2) attendance at the National Governors Council on Science and Technology held in Atlanta on May 19, 1977 for discussion of future activities of the OSTP with representatives of NSF and deputies to Dr. Frank Press, Presidential Science Advisor; (3) preparation of a position statement for the Commonwealth regarding the proposed U.S. Senate Bill S675 presented for Governor Godwin by William J. Hargis, Jr. to the U.S. Senate Subcommittee on Science, Technology and Space; (4) approval of the NSF grant for "science and technology capacity building for state and local policy development"; (5) development of a plan for integrating science and technology in the Commonwealth's decision making; and (6) the appointment of Ertle Thompson on a eight-member task force for implementation of a Virginia Resources Information System under auspices of the Commonwealth's Secretary of Commerce and Resources.

### *Science Education*

Virginia C. Ellett and Arthur W. Burke reported that the fall meeting of the State Science Teachers Conference and Workshop will be held at the Hotel Roanoke on October 27 and 28. The School of Education of the University of Virginia will offer one graduate credit in Earth Science. The topic will be "Meteorology—Weather Prediction and Modification."

### *Science Museum*

E. L. Wisman made two announcements: (1) the Mobile Lounge exhibit "Solar Energy" was parked on the VPI & SU campus during the Academy meeting; and (2) the memory of Dr. Roscoe Hughes was honored by the Science Museum with the dedication and planting of living trees on the Maymont grounds in Richmond.

## Reports From Sections

### *Engineering Section*

Dr. Bishara invited all members of Council to attend a luncheon on Thursday, May 11, 1978 to hear Dr. Walter R. Hibbard speak on "Opportunities for Engineering Research in Coal."

### *Chemistry*

R. G. Bass invited all members to attend the Laboratory Safety symposium scheduled for Thursday afternoon in the Chemistry Section.

### **New Business**

Members expressed concern over the conflict of meeting and examination schedules.

Dr. Allan Powell introduced Frank B. Leftwich, chairperson of the Local Arrangement Committee for the 1979 meeting at the University of Richmond. He also announced that Donald Cochran was working with Dr. Leftwich during this meeting. He reminded all Council members to attend the Academy Conference on Thursday, the Banquet on Thursday evening, and the President's reception at the University club on Wednesday evening.

Later in the evening, the Ad Hoc Committee on the Long-Range Planning of the Journal met to discuss duties of the Business Manager, Section Editors, and the special needs of the editor.

### **The Academy Conference**

May 11, 1978

President Lowry convened the 1978 VAS Conference in VPI's Donaldson Brown Center at 11:40 a.m. on Thursday, May 11, 1978.

*Election* of officers was the first order of business. There being no nominations from the floor, two names were placed for each office:

President-Elect: Herb McKennis, Jr., MCV-VCU; Vera Rensburg, Abingdon High School.

Secretary: K. P. Bovard, VPI & SU; H. G. Marshall, ODU.

Treasurer: D. G. Cochran, VPI & SU; W. R. West, U. Richmond.

E. L. Wisman and Allan Powell were the tellers, and Rensburg, Bovard, and Cochran were declared elected President-Elect, Secretary, and Treasurer, respectively.

### *Virginia Junior Academy of Science*

Dawn Campbell reported that a total of 435 students and 90 teacher-sponsors were registered from 50 high school science clubs. The E. C. Miller Award went to the Pulaski High School Science Club for the third successive year. The proceedings volume was dedicated to Mrs. Vera Rensburg, and the Distinguished Service Award was presented to John L. Hess, the retiring director. Joyce Patterson received the VAS Science Teachers Award, and the Philip Morris Award for outstanding science club sponsors was shared by Elrica Graham and John Joseph of Pulaski High.



President Lowry announced that John Hess was leaving the chair of the VJAS because he will be on sabbatical. The President then recognized the outstanding contributions John Hess made to the Junior Academy during his leadership of the committee.

### *Virginia Journal of Science*

Kuldip P. Chopra reported at the Academy Conference that the Virginia Journal of Science is back on schedule. The Volume 28 (1977) had just been completed, and the Spring 1978 issue should be in the hands of the membership in about four weeks. He summarized the progress made by adding that (a) a very prestigious and experienced editorial board and a dedicated college of section editors has been assembled; (b) an attractive format for the Journal has been adopted; (c) the institutional and disciplinary coverage in the Journal has been expanded; (d) the scope of the Journal has been broadened with the expansion of features, news, notes and announcements; and (e) the size of the Journal has been stabilized for the current volume within our fiscal limits. We need to concentrate on further improvement of the quality and recognition for the Journal while the leadership of the Academy find means to expand its fiscal base.

On behalf of the Editorial Board, the Editor invited the audience to send their manuscripts for possible publication in the Journal, emphasizing that the VJS is still one of the few scientific journals in the country which does not have a page charge.

Dr. Chopra was recognized by outstanding applause from the members in attendance at the Conference.

### *Visiting Scientists Program*

Gerald K. Taylor, Director of the Visiting Scientist Program, reported that during the 1977-78 academic year a total of 976 topics were offered to students in Virginia high schools and science clubs. A total of 612 scientists and educators from 31 universities and colleges in Virginia spoke to a combined audience of 3134 students. Several fine expressions of appreciation for the programs have been received this year.

### *Finance and Endowment Committee*

Rae Carpenter reported that dues income has decreased about 17 percent since 1974, corresponding to a membership decrease which began in 1970. VJS income is now about half what it was a decade ago. The Trust fund for research and income from interest are at an all time high. Receipts exceeded disbursements, producing general fund assets of \$44,442, the highest since 1969. VJS expenses are slightly larger this year than for the last two years since the Journal is attempting to return to its planned publication schedule. He encouraged the membership to invite new members, including several current nonmembers who have presented papers at the Academy's Annual Meeting. Members were advised that the institutions seek increasing accountability for all services that they provide, and the Academy may have to furnish more of the services (secretarial help, business management, editing assistance) currently being offered au gratis.

### *Science Museum*

E. L. Wisman reported that the mobile exhibit on "Solar Energy" was parked on the VPI & SU campus during the Academy meeting. He also noted that the Science Museum honored the late Dr. Roscoe Hughes with the dedication and planting of living trees on the Maysmont Grounds in Richmond.

### *Awards*

Lynn Abbott reported that all awards would be announced and presented at the banquet.

### *Membership*

W. R. West announced the availability of VAS flyers and membership applications. In a review of registration records for the current attendance at the annual meeting, it appeared that nearly 400 persons, students or co-authors, were not members of the VAS. A special effort was made to contact some of these people to invite them to join the Academy.

### *Science Advisory Committee*

Ertle Thompson reported activities since last year's acceptance by the Academy of the concept of the Science Advisory Committee. These activities have resulted in (1) the forum of discussion of future activities of the OSTP with representatives of NSF and the Presidential Science Advisor; (2) the preparation of a position statement for the Commonwealth regarding the proposed U.S. Senate Bill S657; (3) the approval by the NSF of a grant for the Science and Technology Capacity Building for state and local policy development; (4) the appointment of Dr. Don Shull as the coordinator of the Legislative Services; and (5) the appointment of Ertle Thompson to the Task Force on the implementation of a Virginia Resource Information System under the Office of the Secretary of Commerce and Resources.

### *Science Education*

Virginia C. Ellett and Arthur W. Burke reported that the fall meeting of the State Science Teachers Conference and workshop will be held at the Hotel Roanoke on October 27 and 28. The School of Education of the University of Virginia will offer one graduate credit in earth science. The topic will be "Meteorology—Weather Prediction and Modification."

### *State Science Supervisor*

Franklin D. Kizer, retiring Supervisor of Science Education for the State Department of Education, expressed his appreciation for the Academy's role of cooperation and assistance in evaluation of school programs and textbooks, serving on advisory committees, cosponsorship of the annual Science Teachers Conference, and his election as a Fellow of the Academy.

A unanimously approved motion that "the Council prepare a statement to be sent to the State Department of Education expressing the hope of the Academy's continuing its favorable cooperative relationship with the Department in matters of Science Education" was made.

*Local Arrangements Committee*

The Chairperson recognized and thanked the members in attendance of the Local Arrangements Committee. President Lowry formally recognized the outstanding work of Dr. Cochran and his Committee at this time.

*Necrology*

President Lowry asked all in attendance to stand for a moment of silence to honor all Academy members who died during the past year. These included three past presidents: Hiram R. Hanmer (1945-46), Jesse W. Beams (1947-48), and Lloyd C. Bird (1952-53).

*Recognitions*

President Lowry recognized the following for the work of Committees chaired by them: John Hess (VJAS), E. L. Wisman (Nominating), Robert Patterson (Research), and Peter Mazzeo (Virginia Flora). He introduced Dr. Frank Leftwich as Chairperson of the Local Arrangements Committee for the VAS meeting to be held next year at the University of Richmond.

There being no further business, the Academy Conference adjourned at 12:30 p.m.

**The Academy Assembly**

May 11, 1978

Following the Annual Banquet, the Academy Assembly was convened at 8:00 p.m. on May 11, 1978 at the Donaldson Brown Continuing Education Center,

VPI & SU in Blacksburg, Virginia with Dr. Ralph Lowry presiding. Dr. William E. Lavery, President of VPI & SU, welcomed the Academy members and guests to the Tech campus. He was pleased and proud to cite the record of participation by his institute's faculty as members and officers in the Academy.

The following awards were presented to the respective recipients:

Academy Fellows: Arthur W. Burke, Jr. and Herbert McKennis of MCV-VCU, W. Allan Powell of the University of Richmond, and Stanley Ragone of VEPCO.

Honorary Life Member: Beverly Orndorff, science writer for the Richmond Times.

Ivey F. Lewis Distinguished Service Award: Rodney C. Berry, past Executive Secretary-Treasurer of the Academy.

J. Shelton Horsley Research Award: Thomas K. O'Brien and Kenneth L. Reifsnider, Engineering Science and Mechanics Department at VPI & SU for their paper on "Fatigue Damage: Stiffness/Strength Comparisons for Composite Materials," presented as paper No. 2 to the Materials Science Section.

Thomas C. Van Flandern, Chief of the Celestial Mechanics Branch at the U.S. Naval Observatory, Washington, D.C., delivered the Sidney S. Negus Memorial Lecture on the "New Solar System."

The new Academy officers were installed:

President: Dale V. Ulrich, Bridgewater College

President-Elect: Vera B. Remsburg, Patrick Henry High School

Secretary: Ken P. Bovard, VPI & SU

Treasurer: Donald G. Cochran, VPI & SU

The Assembly was adjourned at 9:45 p.m.

**Council Meeting**

May 12, 1978

President Dale Ulrich called to order the breakfast meeting of the Council at 8:10 a.m. on Friday, May 12, 1978. Some of the old and new members of the Council and Frank D. Kizer were present. (*Editors Note: The list of attendees is not available.*)

**Chairpersons of Standing and Ad Hoc Committees***Committee**Chairperson*

Awards  
Constitution and By-Laws  
Finance and Endowment  
Fund Raising  
VJAS Director  
Long-Range Planning  
Membership  
Nominating  
Publications  
Research  
Trust  
Virginia Flora  
Archives (ad hoc)  
Business Relations (ad hoc)  
Science Advisory System (ad hoc)  
Science Museum of Virginia (ad hoc)  
Science Education

Lynn D. Abbott  
Vacant  
D. Rae Carpenter  
J. Samuel Gillespie  
A. B. Niemeyer, Jr.  
Franklin F. Flint  
Warwick R. West, Jr.  
Arthur W. Burke, Jr.  
John H. Wise  
Edgar Spencer  
Stanley Ragone  
Martha K. Roane  
Boyd Harshbarger  
W. Allan Powell  
Ertle Thompson  
Vacant  
Virginia C. Ellett and Arthur Burke



The following is a summary of actions taken by the Council:

*Executive Secretary-Treasurer:* Blanton M. Bruner was reappointed to this position for the 1978-79 Academy year

*VJAS Director:* John L. Hess, the retiring Director of the Virginia Junior Academy of Science, was applauded for three years of distinguished service. Dr. Hess is spending the 1978-79 academic year on a sabbatical at Stanford University.

*VAS Fellows:* E. L. Wisman reported that the Academy has elected 50 Fellows; the first class was elected in 1970. Six of these are now deceased. The third Fellows' breakfast was held on May 11 with 20 in attendance.

*State Department of Education:* President Ulrich was directed (by unanimous vote of the Council) to write to the Governor concerning the selection of a successor to Franklin D. Kizer, the retiring Supervisor of Science Education in the State Department of Education.

*Virginia Journal of Science:* The status and operation of the Journal was reviewed by K. P. Chopra and discussed at length by Council. Publication of the Journal through 1979 (Vol. 30) is planned and budgeted. Options in 1980 are (a) continued publication of the Journal in its present form; (b) publication of the proceedings of the annual meeting; and (c) pub-

lication of a newsletter with or without either of the options (a) or (b). The Publications Committee was directed to prepare a questionnaire to survey Academy members seeking their preferences and suggestions of alternate forms of publication. Resolutions in strong support of continuation of the Journal passed by the Sections on Agricultural Sciences and Botany at this annual meeting were reported to the Council. A motion expressing deep appreciation to Kuldip Chopra for his work with and for VJS over the past 18 months received unanimous approval of the Council.

*Membership Pattern:* W. R. West discussed the pattern of membership changes. He indicated that the recently computerized list of membership reveals that the Academy continues to gain new members, but over the past few years, the membership loss exceeds the gain.

*Election Procedure:* Some shortcomings of the current election procedures and the need for possible changes in these were briefly discussed.

*Local Arrangements:* Don Cochran and his Committee were commended for making excellent arrangements for the Annual Meeting.

*1979 Annual Meeting:* The University of Richmond will host the next annual meeting, which will feature a symposium on "Science Education and State Government."

The meeting adjourned at 12:30 p.m.

# Sidney S. Negus Memorial Lecture

## THE NEW SOLAR SYSTEM

Thomas C. Van Flandern

*Chief, Celestial Mechanics Branch  
U.S. Naval Observatory  
Washington, D.C.*

Dr. Thomas C. Van Flandern, a research astronomer in the Nautical Almanac Office at the U.S. Naval Observatory received his B.S. (1962) in mathematics from Xavier University and Ph.D. (1969) in astronomy from Yale University. He won the second prize offered by the Gravity Research Foundation for his essay on *A Determination of the Rate of Change of G* in 1974. He has authored several popular and scholastic articles, including *Gravitational Constant* for the 1976 McGraw Hill Yearbook of Science and Technology, and *Does the Value of the Gravitational Constant Change?* for the Scientific American. He lectured on the *Time Systems* and the *Solar System Ephemerides* at the Naval Surface Weapons Center in Dahlgren, Va. during 1975.

Dr. Van Flandern is a member of the International Astronomical Union, American Astronomical Society, Royal Astronomical Society, American Geophysical Union, American Physical Society, American Association for the Advancement of Science, and Sigma Xi. He was elected in 1974 to the Council of the American Astronomical Society's Division on Dynamical Astronomy.

His principal research interests include celestial mechanics, lunar motion, and occultation.

## THE NEW SOLAR SYSTEM\*

The old solar system is the one in the textbooks—nine planets with their satellites, some comets and asteroids, with no important alterations over the last

several billion years. The new solar system is by contrast a dynamic place in which catastrophic changes have affected nearly everything. Recent evidence has been presented dealing with each of the following:

The small inner planet Mercury may be an escaped satellite of Venus. The orbit of the Earth's Moon has changed drastically over the last few billion years, partly due to tidal friction and perhaps also due to a general weakening of the universal gravitational constant. The two tiny Martian satellites have undergone intense bombardment, and are likely to be captured asteroids. There is now extensive dynamical, physical and chemical evidence that asteroids and comets were formed from the astronomically recent break-up of a former major planet between Mars and Jupiter. We now know a great deal more about Saturn's mysterious rings, and the even stranger newly discovered rings of Uranus. A new examination of the conjecture that Pluto is an escaped satellite of Neptune has led to some surprising conclusions.

The impact of modern observations and of the space program has been to revolutionize our thinking about the origin and evolution of the solar system faster than new textbooks can be written about it. Nevertheless it can be predicted with certainty that the biggest surprises still lie ahead.

\* Editor's Note: The full text of the lecture was not made available



## 1978 J. Shelton Horsley Research Award Goes to the Materials Scientists at VPI & SU

T. K. O'Brien and K. L. Reifsnider are this year's winners of the J. Shelton Horsley Research Award for their research, and related publication, on the subject of "Fatigue Damage: Stiffness/Strength Comparisons for Composite Materials." The award is the highest honor the Virginia Academy of Science can bestow for original research and its presentation, and was the highlight of the Academy Assembly at the annual meeting held at Virginia Tech this year. An engraved certificate and a monetary award are presented to the winner.

J. Shelton Horsley was an early president of the Virginia Academy of Science who began the endowment, since expanded, which forms the basis for the award. The Horsley family is a famous Virginia family of physicians spanning more than a 150 years from an early family member who was called in to administer to Thomas J. (Stonewall) Jackson during the Civil War, to a recent family member who heads the Virginia Cancer Research Center in Richmond, Va. Competition for the award comes from all fields of research, and all Virginia Academy of Science members, some of whom are from other states, are eligible. The candidate papers are evaluated by a different scholastic society or an academy from outside the State each year. Eight papers were nominated, and the West Virginia chapter of the Sigma Xi picked the winning paper this year.

The research presented in the paper dealt with the use of a reduced stiffness analysis in conjunction with laminated plate theory to predict stiffness changes based on observed debonding and fiber breakage for Boron Epoxy laminates subjected to strain-controlled fatigue loading. All specimens were leached with a heated acid, and fiber breakage was recorded. Correlations were noted between matrix damage and observed change in load-direction stiffness. They made a further attempt to extend this work to completely characterize all four independent material properties—longitudinal and transverse moduli, shear moduli, and Poisson's ratio—for unidirectional Boron Epoxy laminates using a combination of longitudinal, transverse, shear, and bending tests. To insure reproducible and comparable results, they documented the variations in measured material properties with strain gage type and size as well as controlling other variables.

The research which was the subject of their work was carried out in the Department of Engineering Science and Mechanics at VPI and SU under a grant for "Stiffness Analysis of Damage Development in Composite Materials" from the National Science Foundation, and in connection with a contract to study "Frequency Effects on the Fatigue Response of Composite Laminates" sponsored by the Air Force Office of Scientific Research. The paper has been published in the *Journal of Testing and Evaluation*, Vol. 5, No. 5, 384-393 (1977), and its synopsis will appear in the Winter 1978 issue of our journal.

Mr. O'Brien was born December 5, 1949 in Baltimore, Maryland and received his secondary education at Baltimore Polytechnic Institute from which he graduated in 1966. After working for a year and a half for the Chesapeake and Potomac Telephone Company of Maryland, he enrolled at VPI & SU and received a B.S. (with Distinction) in engineering mechanics in 1972. After working for two and a half years for the Proctor and Gamble Company, he returned to Virginia Tech for graduate studies and received his M.S. in 1978. He is a member of the ASTM, SESA, AIAA, Phi Eta Sigma, Tau Beta Pi, and Phi Kappa Phi.

Dr. K. L. Reifsnider, professor of engineering science at VPI & SU, was born February 19, 1940 in Baltimore, Maryland. He received a B.A. (1963) in mathematics from Western Maryland College; B.E.S. (1963) and M.S.E. (1965) in mechanics from the Johns Hopkins University; and Ph.D. (1968) in metallurgy and solid mechanics from the Johns Hopkins University. Since completion of his formal instruction, Dr. Reifsnider has been at Va. Tech. where he is chairperson of the materials engineering science interdisciplinary Ph.D. program. Since 1974, he has chaired the ASTM Subcommittee EO9.03, the national committee responsible for developing standards for testing and design of components involving composite materials subjected to cyclic loading. He is the author of some 30 papers, and a member of the editorial board of the *International Journal of Fatigue*. He is the originator, and current chairperson of the editorial board, of the *Applied Composites Review*. Dr. Reifsnider has lectured in Asia and Europe as a NATO materials science consultant under the sponsorship of AGARD. He is a past chairperson of the VAS' section on materials science.

# THE NEW ACADEMY OFFICERS

## PRESIDENT

Biographical Information  
Not Available



From left to right are Don Cochran, Ken Bovard, Vera Remsburg, and Dale Ulrich.

## SECRETARY

Dr. Kenly P. Bovard, associate professor of genetics in the Department of Animal Science at VPI & SU, was elected secretary of the Virginia Academy of Science at the Academy Conference and installed as such at the Academy Assembly.

Dr. Bovard received his B.S. (1950) at Cornell University, and M.S. (1954) in animal science and Ph.D. (1960) in animal breeding and genetics from Iowa State University. During 1957-73, he served VPI as the geneticist with the Front Royal Beef Cattle Research Station, a cooperative program with the USDA. Since 1973, Dr. Bovard has been in Blacksburg, teaching applied animal genetics and continuing research with the Front Royal data.

Ken has served the Journal of Animal Science, as a member of its editorial board, and the American Genetic Association as its secretary and a member of its Council. He has also been actively involved in Sigma Xi, Gamma Sigma Delta, and the Virginia Academy of Science.

## PRESIDENT-ELECT

Vera B. Remsburg, chairperson of the Science Department at Patrick Henry High School in Washington County was elected president-elect at the Academy Conference held on May 11, 1978 and installed in that capacity at the Academy Assembly held the same day. A high school biology teacher, she is the second woman elected to that office in an organization of about 1500 scientists from around the state. Ida Siller of Hollins College was the only other woman president of the Academy in 1935-36.

Mrs. Remsburg received her B.S. (1942) and M.A. (1952) in biology from Longwood College and U.Va., respectively. She has pursued advanced studies at the College of William and Mary, U.Va., Roanoke College, VPI & SU, and George Washington University.

Vera has been one of the most dedicated members of the Academy, contributing her time and energy in many capacities: member, VJAS committee (17 years), secretary and chairperson (biology section), Va. Flora committee (3 years), chairperson and secretary (science teachers section), member of the resolutions and long-range planning committees, chairperson of the awards committee, etc. She was treasurer and acting secretary of the VAS last year.

Professional awards and honors bestowed upon Mrs. Remsburg include: 1958 distinguished service award of the American Chemical Society (Virginia section); 1968 distinguished biology teacher in Virginia award of the National Association of Biology Teachers; distinguished service award of the Virginia Junior Academy of Science (1973). She was elected fellow of the VAS in 1975. Someone described her well by saying: Vera Remsburg perpetuates the spirit of science.

## TREASURER

Dr. Donald G. Cochran, professor of entomology at VPI & SU was elected the Academy's treasurer at the Academy Conference and installed in that capacity at the Academy Assembly.

Dr. Cochran received his B.S. (Iowa State University), M.S. (VPI & SU) and Ph.D. (Rutgers University). At VPI & SU, he teaches and conducts research in insect physiology, genetics and cytogenetics, and insecticide toxicology.

Don is a member of the Entomological Society of America, American Association for the Advancement of Science, the American Genetics Association, and Sigma Xi. He has ably served the Virginia Academy of Science as a member of the long-range planning committee, VJAS committee, and the local arrangements committee (1971, 1978), serving as chairperson in 1978.



## Abstracts of Papers Section of Agricultural Sciences

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

THE PATHOGENICITY ON TOBACCO (*NICOTIANA TABACUM* L.) OF *CORYNESPORA CASSIICOLA* ISOLATED FROM SEVERAL DIFFERENT SOURCES. J. C. Adams\*, L. D. Moore and M. K. Roane. Dept. of Plant Pathology and Physiology, V.P.I.&S.U., Blacksburg, Va. 24061.

*Corynespora cassiicola* (Berk.&Gurt.) Wei, a common pathogen of vegetable crops in tropical and subtropical areas, causes a disease known as "target spot." An isolate of *C. cassiicola* from tobacco field soil in Virginia (VI) was compared with 4 isolates from Wisconsin (CC1 CC2, CC3, and CC5), and one isolate from Florida (ATCC 16718). Radial growth and dry weight, macro- and microscopic characteristics, and the ability to incite disease on tobacco and several other crops were noted. Compared to the others, VI is a slow-growing isolate and is probably only a secondary invader. The possibility that there is a mycovirus in VI is presently being investigated.

ASPECTS OF GERMAN COCKROACH BEHAVIOR. R. C. Akers\*. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The circadian activity patterns of adult German cockroaches, *Blattella germanica* (L.), were investigated. The activity of three cockroach strains: genetically-marked black body; field collected; and laboratory wild-type cockroaches were studied. Information was obtained from observations of cockroaches enclosed in a simulated kitchen-cabinet environment. Observations were made at 15 min. intervals, from 10:00 p.m. to 5:00 a.m., for 21 hrs for each cockroach strain. Observations were replicated 3 times.

The observation data indicate two distinct activity periods for all three strains: a night peak occurring at about 11:00 p.m.; and a morning peak at about 5:00 a.m. Between these peaks the cockroaches returned to their harborage or otherwise remained inactive.

USE OF NURSE CROPS IN VIRGINIA AS A METHOD FOR DISPERSING *PEDIOBIUS FOVEOLATUS*, A PARASITE OF THE MEXICAN BEAN BEETLE. W. A. Allen, P. B. Schultz and D. W. Craun, Dept. of Entomol., VPI and SU, Blacksburg, Va. 24061; Va. Truck and Orna. Res. Sta., Norfolk, Va., and Va. Dept. of Agric. and Comm., Norfolk, Va.

*Pediobius foveolatus* (Crawford) an imported Eulophid parasite of the Mexican bean beetle, *Epilachna varivestis* Mulsant has been annually re-established using nurse plots in Virginia during the past 3 years. Nurse plots interplanted with snapbeans and soybeans successfully established the parasite with an average initial establishment time of 13.3 days in 1976 and 35.7 days in 1977. The parasite dispersed over a distance of 126 miles in 1977 and proved to have excellent search capabilities at low host densities. Sixty-one percent of all larvae detected in October, 1977 were parasitized.

SEASONAL VARIATION IN PALATABILITY OF FESCUE FORAGE. C. P. Bagley, J. P. Fontenot, R. E. Blaser and K. E. Webb, Jr. Virginia Polytechnic Inst. and State Univ., Blacksburg, Va.

Three palatability trials were conducted with Ky 31 tall fescue beginning May 7, July 21 and November 3. Crossbred wethers were fed freshly harvested tall fescue or alfalfa hay (reference feed) twice daily in individual pens. The .5 ha fescue plot was fertilized with 56 kg each of nitrogen, phosphorus and potassium on April 13 for summer growth, and 101 kg of nitrogen/ha on August 11 for fall accumulation. Fescue used in the palatability trials was harvested once daily with a mower at 4 cm from ground level, and the forage was chopped prior to feeding. Fescue forage was in the late boot stage in May and the vegetative stage in July and November. Total dry matter intake was 76.6, 82.2 and 57.9 g/kg<sup>.75</sup> for fescue and 121.3, 113.5 and 68.4 g/kg<sup>.75</sup> for alfalfa hay in May, July and November, respectively. Fescue intake, as a percent of the reference feed, was 63.3, 72.1 and 87.7 for the respective months. Relative intake was highest for November (P<.05). Total nonstructural carbohydrates were 13.9, 9.9 and 15.9%, and crude protein was 10.4, 10.3 and 10.6%, dry basis, in May, July and November, respectively. *In vitro* dry matter disappearance was 67.2, 62.8 and 68.5% for the respective months. It appears that highest intake of fescue occurs when the total nonstructural carbohydrate level is highest.

INSECTS ASSOCIATED WITH HORSENETTLE (*SOLANUM CAROLINENSE* L.) IN SOUTHWEST VIRGINIA. T. E. Bailey\* and L. T. Kok, Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

As part of a project to study indigenous phytophagous insects of selected and important weeds in Virginia, a survey of insects which feed on horsenettle in south-west Virginia was conducted between 1972 and 1977. Most frequently encountered were a number of general feeders, several pests of economic plants, and a few relatively specific feeders. Among the economically important species were: the pepper maggot, *Zonosemata electa*; the tobacco hornworm, *Manduca sexta*; several flea beetle species including *Epitrix fuscata* and other *Epitrix* species; and the potato vine borer, *Trichobaris trinitata*. Species which were innocuous and possibly beneficial in terms of their damage to horsenettle included: a weevil species of the genus *Apion*, a tortoise beetle, *Coplocylla clavata*; a close relative of the Colorado potato beetle, *Leptinotarsa juncea*; and a gelechiid moth *Frumenta nundinella*. Detailed biological studies were conducted on some of the above species to evaluate their potential for causing damage to the horsenettle plant. Included were observations on their distribution and abundance, life-history, host specificity and impact on the weed.

EFFECTS OF HERBICIDES ON THE GROWTH OF *CYLINDROCLADIUM CROTOLARIAE*. J. A. Barron, III, Dept. of Plant Pathology & Physiology, VPI & SU, Blacksburg, VA 24061

*Cylindrocladium black rot*, caused by the fungus *Cylindrocladium crotolariae*, is an important soilborne disease of peanut in Virginia and North Carolina. An experiment was initiated to determine the effects of several herbicides used in peanut production on growth of *C. crotolariae* in vitro. Potato-dextrose broth was amended with sterile solutions of herbicides in water or acetone at concentrations of 0, 5, 10, 20, 30, 50 and 80 µg/ml active ingredient and was then inoculated with 13 mg of washed mycelium. After 10 days of stationary incubation, cultures were washed and collected on tared filter papers with suction, then dried and weighed. Mycelial dry weights of cultures amended with commercial formulations containing alachlor, benefin, vernolate and 2,4-DB, or with technically pure dinitramine were not significantly different from those of unamended cultures. Growth of the fungus was significantly reduced, however, when the medium was supplemented with formulations of dinoseb, dinitramine and dinoseb + naptalam, or with technically pure dinoseb supplied as the parent phenol molecule.

DIGESTIBILITY OF ENSILED SWINE WASTE AND GROUND CORN GRAIN BY GILTS. J. C. A. Berger, E. T. Kornegay, J. P. Fontenot, and K. E. Webb, Jr. Dept. of Animal Science, VPI&SU, Blacksburg, Va. 24060

Fresh swine manure was collected under slotted floors at 3 day intervals from growing finishing swine fed a typical corn-soybean meal diet (16% C.P.). The fresh swine waste was then mixed with ground corn grain and ensiled a minimum of 45 days in 208 l steel barrels lined with double thickness plastic bags. Proportions of swine waste: corn were 60:40 and 40:60. All silages were analyzed initially and upon opening for pH, lactic acid, soluble carbohydrates, volatile fatty acids, and microbial determinations. Three digestion trials, consisting of a 7 day preliminary period and a 5 day collection period, were conducted with 10 crossbred gilts weighing approximately 90 kg. Diets for the digestion trials were 1). Basal (corn-soybean meal diet, 14% crude protein), 2). 75% Basal + 25% 40:60 silage, 3). 50% Basal and 50% 40:60 silage, 4). 75% Basal + 25% 60:40 silage and 5). 50% Basal + 50% 60:40 silage. The apparent digestibility of dry matter, crude protein, and crude fiber was decreased with increasing amounts of the silage in the ration. Apparent crude protein digestibilities for diets 1, 2, 3, 4 and 5 were 88.5, 87.6, 84.5, 82.7 and 82.8 respectively. The dry matter digestibility by difference for the 60:40 silage and 40:60 silages were 77% and 82.5% respectively. Crude protein digestibility by difference was lower for the 60:40 (71.2%) than the 40:60 (82.66%).

COMPARISON OF HYDROMETER AND PIPETTE METHODS OF PARTICLE SIZE ANALYSIS. A. C. Blackburn, C. D. Peacock, and J. L. Richardson. Dept. of Agronomy, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The Bouyoucos 2-hour hydrometer method of particle size analysis is a quick, inexpensive method of estimating the clay and silt content of soil samples. The present study was conducted to compare this method with the standard but more costly and lengthy pipette method. It was found that subtracting 3.7 percent from the clay and adding to the silt increased reading accuracy. The regression model that best fits the 109 comparisons available is clay value = (1.0) (hydrometer clay reading) - 3.7 ± 1.0. This yields a highly significant correlation of .95. It was found that the regression line and standard error of the estimate changed between the three laboratories tested. The difference between the laboratories is statistically significant and, therefore, a separate regression to correct the hydrometer reading increased the reliability of the measures. The largest degree of error was found in soil samples with greater than 40 percent silt. The correlation coefficient drops to 0.85 and the standard error of the estimate increased 3.1. Additionally, the variability of sand increased in high silt samples.

GROWTH AND NUTRITION OF LOBLOLLY PINE SEEDLINGS UNDER VARIOUS SOIL PHOSPHORUS REGIMES. D. E. Bowling\* and J. D. Gregory. Dept. of Forestry and Forest Products, Virginia Polytechnic Inst., Blacksburg, VA 24061.

Loblolly pine seedlings were grown for fourteen weeks on the A horizon of a Bayou soil found in the Virginia Lower Coastal Plain. The soil phosphorus regime was manipulated by additions of triple super phosphate and dolomitic limestone and control of the moisture content. The phosphorus status of the soil was investigated with a modified Chang and Jackson fractionation of soil phosphorus, organic phosphorus by the ignition method, and 0.05 N HCl in 0.025 N H<sub>2</sub>SO<sub>4</sub> extraction for available phosphorus.

The height and mass of the seedlings were measured along with determination of the nutrient status by extraction with 0.3 N HNO<sub>3</sub> after ashing. Through statistical analysis the growth and nutrient status of the seedlings were related to the soil phosphorus regime.

CALVING DIFFICULTIES AT FRONT ROYAL: A SUMMARY. K. P. Bovard, Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061.

Three previous reports to the Virginia Academy of Science have dealt with slightly different aspects of the subject. Data came from the VPI-USDA cooperative beef cattle breeding experiment at the Front Royal Station. Records were from years 1958-1969. In 1972, a study of 3491 single births showed < 8% stillborn; < 4% pulled; and, < 2% posterior (breech) presentation. From 3125 born alive unassisted, 92.5% lived to weaning, gained 1.66 lb/day. In contrast, from 98 calves born alive with assistance, 81.6% was weaned, gained 1.61 lb/day, N.S. In 1976, a study of 4023 births showed 3585 (89.11%) born alive unassisted. Product-moment correlation of presentation -- vertex or posterior -- with assistance -- none or needed -- was 0.483. Correlation of calf's and dam's scores on calving difficulty was 0.025, not different from zero. In 1977, a study of 5147 matings showed linear regression of type-of-birth score on dam's age was -0.061 ± .008, with r<sup>2</sup> = 0.014, and Y = 1.427. Calving difficulties are most common among young primiparous cows, especially with male rather than female calves.



THE EFFECTS OF SUPPLEMENTAL CHOLINE ON SOW AND PIG PERFORMANCE. K. L. Bryant, G. E. Combs, H. D. Wallace, and J. P. Feaster. Dept. of Animal Science, Univ. of Fl., Gainesville, Fl. 32611

Two-hundred and two litters were utilized to evaluate the effects of two levels of supplemental choline (0 and 1000 mg/kg diet) in the gestation and lactation diets of swine. Experiment 1, involving 87 litters, started at the 110th day of gestation and concluded at 21 days post-partum. All normal production criteria favored the 1000 mg supplemented sows. However, the only criteria significantly ( $P < .05$ ) affected were the average weaning weight per pig and the average sow weight change. The sire of the litter had a significant effect ( $P < .01$ ) on the occurrence of spraddled-leg pigs. This indicates a possible hereditary involvement with this condition, rather than a nutritional one. Experiment 2, involving 115 litters, utilized two sow diets (basal and sow bulk) and two levels of supplemental choline (0 and 1000 mg/kg). The four diets were fed throughout the females' entire production cycle. Significant differences ( $P < .05$ ) were observed between the four diets for some criteria, however, none of these differences could be related to the level of supplemental choline or type of sow diet. The small number of litters utilized and the large variation between sows is believed to be the cause of these differences. When the basal and low bulk diets were combined for each level of supplemental choline the results for all criteria, except weaning weight, favored the 1000 mg supplemented sows.

MATING BEHAVIOR OF DWARF AND NONDWARF CHICKENS. Cathy Caplan, Paul B. Siegel and Harry P. Van Krey, Poultry Science Department, VPI & SU, Blacksburg, VA 24061.

The sex-linked recessive dwarf gene was introduced into the 13th generation of lines of White Plymouth Rocks selected for high and low body weight. Heterozygous males were then backcrossed to normal females from their respective selected lines. The chickens reported on here were from the 6th backcross generation, and were widely diverse for allomorphic traits. For example, at 232 days of age the mean weight of high weight normal males was 4.4 Kg while that for the low weight dwarfs was 0.9 Kg. Respective values for females were 3.9 and 0.8 Kg. Similar diversity among genotypes also existed for skeletal measurements such as the length of the metatarsus. Highly significant differences were found among male genotypes for number of completed matings when tested with normal and dwarf females of these lines. The cause of these differences were due to both libido and mechanical factors. Although significant differences were found among male genotypes for semen characteristics, there was no effect on fertility via artificial insemination. Thus, these data indicate that fertility per se is a combination of behavioral, morphological, and physiological characteristics working in concert.

A CHARACTERIZATION OF INTERSEXUALITY IN SWINE. J. W. Knight\*, H. G. Kattest\* and J. S. Claus\*. Department of Animal Science, VPI&SU, Blacksburg, VA 24061

A pseudohermaphrodite swine was characterized phenotypically, morphologically, and by selected endocrine parameters. The external genitalia appeared predominately female, with an upturned elongated vulva and an enlarged protruding clitoris. A normally developed scrotum contained one testis, the second testis being abdominal. Upon slaughter, the reproductive tract was removed and examined. The testes, with fully developed epididymides, led to a structure resembling an oviduct, well developed uterine horns and body, cervix, and vagina. Within the vagina was a coiled internal penis which continued externally as the enlarged clitoris. Superimposed upon this "female" tract was a full complement of male accessory glands (seminal vesicles, prostate and bulbo-urethral glands). Behaviorally, the animal resembled a normal boar, salivating and mounting when exposed to a gilt in estrus. At approximately ten months of age, an indwelling catheter was placed in the left anterior vena cava and blood samples were collected daily for two weeks and every 30 min over a consecutive 24 hr period. Samples were also taken following exogenous challenges with testosterone and HCG. All samples are being analyzed for testosterone and these data will be presented.

ILLUSTRATING YOUR PUBLICATIONS: WHAT YOU SHOULD KNOW.

A. F. Buckman\*, Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

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ASPECTS OF OLDHOUSE BORER BIOLOGY AND DISTRIBUTION IN VIRGINIA (COLEOPTERA: CERAMBYCIDAE). K. F. Cannon\*, Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

The family Cerambycidae, long-horned beetles, includes over 1200 North American species. Most species of the family are wood-boring in the larval stage; many species are destructive to shade and forest trees, and to freshly cut logs. The life cycle and larval feeding habits of the oldhouse borer, *Hytotrupes bajulus*, are unique in the family. The larval stage of *H. bajulus* feed on seasoned soft woods, and is a structural pest in eastern North America.

A laboratory colony of *H. bajulus* was established to study the North American and European biotypes of *H. bajulus*. A survey of professional pest control operators and homeowners was conducted to establish the distribution of this beetle in Virginia.

Preliminary data indicate slight differences in two biotypes. Distribution in Virginia varies according to geographic region.

CHANGES IN CHARACTERISTICS OF DEEP STACKED BROILER LITTER WITH TIME. G. R. Dana, J. P. Fontenot, J. A. Duque and K. E. Webb, Jr., Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Approximately 20 metric tons of litter were collected from a broiler house and stacked in a covered building open on all sides. Thermistor probes were placed at depths of 46 and 81 cm from the top of the stack, and temperature was monitored daily. Temperatures within the stack were consistently higher at 46 cm than at 81 cm. Maximum temperature was reached at 7 days at the 46 cm depth (54 C) and at 17 days at the 81 cm depth (48 C). The pH increased from 7.38 initially to 8.04 after 1 week ( $P < .01$ ). Lactic acid was .27% of the dry matter, initially. After 3 weeks, the level dropped to a value of .04%, dry basis ( $P < .01$ ). Acetic acid, was .64%, dry basis, initially, increased ( $P < .01$ ) to 1.7%, dry basis, after 1 week, and varied between 1.0 and 1.6% thereafter. The other volatile fatty acids increased at the end of 1 week. Soluble carbohydrates tended to rise with time in the stacked litter. No fecal coliforms and few total coliforms were detected in the litter at any time. *Salmonella* and *shigella* were not observed and proteus growth was noted from weeks 2 to 5. Small laboratory silos were made weekly from the stacked litter alone and with added moisture to a moisture level of 40%. One half of the silos were opened at 28 days and the others were opened after 42 days. The pH was lower for the ensiled material to which moisture had been added.

# FERMENTATION AND DIGESTIBILITY OF BROILER LITTER ENSILED AT DIFFERENT MOISTURE LEVELS BY ADDITION OF WHEY OR WATER.

J. A. Duque, J. P. Fontenot, K. E. Webb, Jr. and J. C. A. Berger, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

A laboratory study was conducted to determine the feasibility of ensiling wood shaving based broiler litter (13% moisture) alone and with the addition of water or whey (93% moisture) to obtain moisture levels of 30,40,50,60 and 70%. The pH was lower ( $P < .01$ ) and lactic acid was higher ( $P < .01$ ) for silages with added moisture from the addition of water or whey. Lactic and acetic levels tended to be higher for the silages containing whey, compared to those with added water. Optimum fermentation was observed at 40 and 50% moisture levels, supplied by whey or water. General appearance and smell of the 60 and 70% moisture litter silages were unfavorable. Total coliforms and proteus organisms were eliminated by ensiling. Wethers were fed a low protein basal ration alone or supplemented with ensiled litter with no added moisture and added moisture to 30, 40 and 50% from water and whey, or soybean meal in two metabolism trials. The supplements provided 50% of the dietary nitrogen. There were no significant differences in digestibility of dry matter among the rations supplemented with the broiler litter silages and soybean meal. Nitrogen retention (g/day) was not significantly different among lambs fed the supplemented rations.

# A SELF-PROPELLED MODEL TRACTOR FOR TRACTION AND DYNAMIC BEHAVIOR STUDIES.

D. M. Durant\* and Dr. J. V. Perumpral\*, Dept. of Agricultural Engineering, V.P.I. and S.U., Blacksburg, Va. 24061.

A self-propelled model tractor and the necessary instrumentation for continuous recording of weight distribution and drawbar pull were developed. The tractor and instrumented platform were developed for classroom demonstrations for demonstrating the effects of selected variables on the traction force the tractor can develop. The variables considered included the center of gravity location, drawbar pull angle, traction surface, rear axle torque and the slope of the traction plane. The model tractor design included constant torque input at the rear axle, two test speeds and tires which are flexible to simulate a pneumatic tire. The design of the test platform included load sensors for measuring, on a continuous basis, the drawbar pull and weight distribution and provisions for providing different traction surfaces. The measurement of forces were accomplished with the help of strain gages mounted on aluminum cantilever beams. Instruments used for recording the bridge output included an Accudata 218 Bridge Amplifier and a 12-channel visicorder, model 1508; all manufactured by Honeywell. The test results with the model tractor indicated that it can be used for demonstrating the effect of the traction variables on the traction force in the classroom.

# HORSENETTLE CONTROL IN PASTURE.

R. M. Gorrell, S. W. Bingham, and C. L. Foy. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. 24061.

Field studies were conducted on unimproved bluegrass pastures in Va. in order to determine the number and feasibility of repeated annual herbicide applications for the control of the foliage and extensive root system of established horsenettle stands. In these studies, two annual applications of picloram (4-amino-3,5,6-trichloropicolinic acid) at .25 lb/a and picloram plus 2,4-D (2,4-dichlorophenoxy) acetic acid at 1 lb/a provided superior control of the shoots; however, dicamba (3,6-dichloro-o-anisic acid) at .5 lb/a, triclopyr [3,5,6-trichloro-2-pyridinyloxy]acetic acid at 1.5 and 3 lb/a, 2,4,5-T (2,4,5-trichlorophenoxy) acetic acid at 1 lb/a, silvex [2-(2,4,5-trichlorophenoxy) propionic acid] at 1 and 1.5 lb/a and combinations of these with 2,4-D also provided good control. The number of plants per plot observed the next year following the first treatment application was decidedly less in most of the treated plots indicating the suppression or partial destruction of the root system. Again picloram seemed to give the better results.

# REPRODUCTION OF *HETERODERA SCHACHTII* AND *H. GLYCINES* ON SELECTED PLANTS OF THE CHENOPODIACEAE, CRUCIFERAE, LEGUMINOSAE AND SOLANACEAE.

Lorraine O. Graney and L. I. Miller. Dept. of Plant Path. & Phys., V.P.I. & S.U., Blacksburg, Va. 24061

The ability of the Steele isolate of *Heterodera schachtii* (SCH) and the Miss.1 and N.C.1 isolates (I) of *H. glycines* (GLY) to develop egg-bearing females was tested on the following plants: *Solanum dulcamara* (bittersweet nightshade), *S. tuberosum* ('Pontiac' potato), *Nicotiana tabacum* ('NC 95' tobacco), *Lycopersicon esculentum* ('Pearson A 1' tomato), *Capsicum frutescens* ('California Wonder' pepper), *Glycine max* ('Lee' soybean), *Arachis hypogaea* ('Florigiant' peanut), *Brassica oleracea* var. *capitata* ('Chieftan Drumhead' cabbage), and *Beta vulgaris* ('US 75' sugar beet). Inoculum of 25 cysts of SCH and each of the I of GLY was added to cyst-free soil in 100mm pots. A single seedling or seed piece was transplanted or planted to each pot, and after 7 weeks roots were examined for the presence of fifth-stage females. No females of SCH and the I of GLY were formed on bittersweet nightshade, potato, tobacco, pepper and peanut. A few females were formed on tomato by SCH and I of GLY. Numerous females were formed on soybean by I of GLY but none were formed by SCH. Numerous females of SCH were formed on cabbage; none were formed by the Miss.1 of GLY, but a few were formed on one plant of 4 replicates by the N.C.1 I. Numerous females of SCH were formed on sugar beet but no females of the I of GLY were formed on sugar beet.

# REFORESTATION IN THE REPUBLIC OF HAITI.

J. D. Gregory and J. R. Johnson\*. Dept. of Forestry and Forest Products, Va. Polytechnic Inst., Blacksburg, VA 24061

The Department of Forestry and Forest Products is providing technical assistance to the Haitian-American Community Help Organization for the development of a reforestation program for the Republic of Haiti. The country has an extensive erosion problem stemming from deforestation, overgrazing and tillage of unsuitable sites. Forest resources are needed for production of charcoal and lumber. A large nursery is producing containerized seedlings and species test trials have been established. Outplanting projects combine trees with contour canals, terraces, and gully stabilization measures.

# EFFECT OF HYPERTONIC SALINE FLUSHING ON CONCEPTION RATE IN DAIRY COWS.

M. B. Guise\*, F. C. Gwazdauskas and J. A. Lineweaver. Dept. of Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The uteri of twelve uni- or multiparous Holstein or Jersey cows were flushed with sterile saline during the estrous cycle. Each cow was flushed twice, once at estrus and randomly again at 5, 10 or 15 days postestrus. The anal and vulvar region was scrubbed with soap and water and rinsed with 2% iodine in 70% ethanol. A Fr. 20 Foley catheter containing 2.25 mm polyethylene tubing was inserted through the cervix and into one uterine horn at least 3 cm beyond the palpable uterine bifurcation. Fifty ml of sterile 1.5% (.33 M) sodium chloride solution followed by a 100 ml volume of atmospheric air was introduced into the uterine horn. Using gentle massage, the fluid was withdrawn with the assistance of a 100 mm Hg pressure supplied via a vacuum pump. Fluid recovery ranged from 10-80% with an average of 42.67%. Conception rate (CR) per service on the first two breedings and services per conception (S/C) on the flushed cows was 75% and 1.77, respectively compared to 51% and 2.06 for comparable breedings in other herd cattle. The results suggest that hypertonic saline flushing does not reduce CR or increase S/C, two parameters indicative of livestock reproductive efficiency.



EFFECT OF XYLAZINE HYDROCHLORIDE ON MILK PRODUCTION OF DAIRY COWS. M. B. Guise\*, F. C. Gwazdauskas and J. A. Lineweaver. Dept. of Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Fifty-two lactating cows in mid or late lactation were injected intramuscularly with 30 mg of xylazine hydrochloride in order to cause a quiescence of rectum contractility so that rectal palpation could be used to flush the uterus with hypertonic saline. The 30 mg dose of xylazine hydrochloride did not cause recumbancy. Milk weights for pre-treatment (n=3), day of treatment (n=1), and post-treatment (n=3) were analyzed using a complete randomized block design. Time of day (AM vs PM) milk weight was utilized in each block. Pretreatment and post treatment milk weights averaged ( $\bar{X}$ ±SE) 13.60 ± 0.66 kg and 13.44 ± 1.14 kg, respectively, while the day of treatment milk yield was 13.57 ± 0.73 kg. Simple one-way analysis of variance showed that there was no significant difference ( $P>.10$ ) between milk weights. Xylazine hydrochloride produced no detrimental effect on milk production in lactating dairy cows.

APPLICATION OF SOLAR ENERGY FOR HEATING LIVESTOCK BUILDINGS. D. H. Vaughan, B. J. Holmes\*, and E. S. Bell\*, Dept. of Agricultural Engineering, VPI&SU, Blacksburg, Va. 24061

A fully automated solar-heated swine nursery facility was designed and constructed and has been performance tested during the winter of 77-78. The nursery building houses 36 pigs in triple-decked cages and is heated with a solar-assisted water-to-air heat pump. Flat-plate water-cooled solar panels collect the sun's heat which is then used to heat the water source to the heat pump. When heat is not required by the nursery, the solar heat is stored in an insulated thermal storage water pond for use at night or when solar energy is not available. The pond, equipped with a coiled plastic pipe heat exchanger, was designed to be low-cost and easy to build and maintain by the farmer. Three groups of pigs were produced in the facility during the past winter. Data collected included air and water system temperatures, solar insolation available, electricity consumption of the heat pump, water pump, auxiliary heater, and ventilation fan, and liquid flow rates. Data was collected and logged onto the VPI&SU central campus computer using a programmable data acquisition system and a data terminal with tape recorder. An event recorder was used to monitor times of operation of the electrical components. Except for a few extended cloudy and rainy periods, auxiliary heat was not needed. The building temperature was maintained at 20-28°C, depending on the age of the pigs, while the storage pond temperature varied from 10-35°C. (Research supported by USDA/ARS and DOE.)

CELLULOSE CROPS FOR USE IN THE PETROCHEMICAL INDUSTRY. H.A. Hughes\*, D.H. Vaughan, and B.J. Holmes\*. Dept. of Agricultural Engineering, VPI&SU, Blacksburg, VA 24061.

The feasibility of producing cellulose crops for use in making substitute fuels for the petrochemical industry was investigated. The crops evaluated were Eucalyptus, Kenaf, Bamboo, Napier Grass, Tropical Sorghums, Cassava, and Loblolly Pine. Individual reports were prepared on each crop detailing productivity, nutrient requirements, disease and insect susceptibility, production and harvesting processes, energy requirements, climatic needs, and other similar data. A computer program was prepared to simulate the production of each crop and selected combinations. It was assumed, for purpose of comparison, that 500,000 tons of dry matter must be produced within a 30-mile radius from a central processing plant. Factors such as soil trafficability, climate, fertilizer requirements, yield prediction, land needs, farm layout, machinery requirements, field operation scheduling, and transportation on the farm and to the plant were considered. At the large acreages examined, costs generally varied linearly with area and no significant scale economics were identified. Napier Grass was the most productive crop with a predicted yield as high as 63,310 lb/ac of dry matter. The tree crops, Sycamore and Eucalyptus, had much lower yields than the other crops. The high yielding crops, Kenaf and N. Grass, had the largest power requirements and highest cost for field machinery. (Research supported by Gulf Oil Chemicals, Inc.).

EFFECT OF ZINC ON PEANUTS IN VIRGINIA. D. L. Hallock, Tidewater Research and Continuing Education Center, Va. Polytechnic Inst. and State Univ., Holland Station, Suffolk, Va. 23437

Increased Zn fertilization on corn concerns Virginia peanut producers relative to possible toxic Zn level development. An experiment was conducted in 1977 on Fuquay fine sandy loam to investigate effects of several rates of applied Zn on peanut productivity. Zinc sulfate was applied about 15 days prior to planting before plowing and after plowing, then disked in. Rates of Zn applied in each case were 0, 11.2, 22.4, 33.6, and 44.8 kg/ha.

Peanut yield and crop value were significantly higher for the 33.6-kg rate than for the 44.8-kg rate when Zn was applied after plowing. However, none of the rates significantly effected productivity relative to the check. Average productivity was slightly higher where Zn was plowed under than where disked (\$1,420/ha vs \$1,325/ha). Foliar Zn contents increased up to 156 ppm as Zn rates increased. No toxicity symptoms were observed. Method of incorporation did not affect foliar Zn but EDTA-(NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>-extractable soil Zn levels were highest (up to 6.5 ppm) when applied Zn was disked in. Previous research elsewhere indicated critical Zn toxicity levels in peanut foliage and soil approximate 220 and 12 ppm, respectively. Hence, general Zn toxicity in peanuts appears unlikely in the near future.

ENERGY CONSUMPTION IN VIRGINIA AGRICULTURE. H. A. Hughes\* and D. H. Vaughan. Dept. of Agricultural Engineering, VPI&SU, Blacksburg, VA 24061.

Agriculture is an energy intensive industry. Increased energy use in agriculture was a major reason for the decrease in labor and land requirements that occurred during the last 25 years. Agriculture is in an anomalous position in terms of national energy policy. Agricultural energy, about 3% of national consumption, is too large to ignore but too small to receive a great deal of attention from policymakers. However, because of seasonality and the need for uninterrupted supplies to prevent catastrophic losses, agricultural energy use is inherently different than many other energy uses. In the event of another embargo, it will be essential to have estimates of fuel requirements for various agricultural enterprises so that adequate fuel can be allocated to agriculture. Using 1974 production data as a base, this analysis showed that Virginia agriculture required 12,854 billion Btu of energy. Flue-cured tobacco required the most energy (3446.2 x 10<sup>9</sup> Btu) and the most energy per acre (49.23 x 10<sup>6</sup> Btu/ac) of any crop grown in the state. Other crops requiring large quantities of energy were corn (1713.2 x 10<sup>9</sup> Btu) and soybeans (871.4 x 10<sup>9</sup> Btu). On a per acre basis, both of these crops were much lower than tobacco (2.79 x 10<sup>6</sup> Btu/ac and 2.13 x 10<sup>6</sup> Btu/ac, respectively). Beef cows and calves and broilers, because of the large numbers involved were the biggest energy users in animal agriculture at 870.7 x 10<sup>9</sup> and 640.6 x 10<sup>9</sup>, respectively.

DEVELOPMENT OF FOREST TREE NURSERIES IN THE REPUBLIC OF HAITI. J. R. Johnson\* and J. D. Gregory. Dept. of Forestry and Forest Products, Va. Polytechnic Inst., Blacksburg, VA 24061

As part of an intensive soil conservation and reforestation program initiated in the Northwest Department of the Republic of Haiti, a network of forest tree nurseries was established. Various nursery techniques were tested to find those which would maximize production of a wide variety of tropical and subtropical tree species.

Rapid production of plantable nursery stock was the objective of highest priority throughout the life of the project. Research on species adaptability and productivity on the various sites in the Northwest was conducted at the same time. Initial results of these species trials are now being incorporated into the nursery operations.

EFFECTS OF PLANT BED COVER MATERIALS ON STAND AND GROWTH OF TRANSPLANTS AND FIELD PERFORMANCE OF TOBACCO. J. L. Jones, Southern Piedmont Ctr., VPI & SU, Blackstone, Va. 23824

The comparative effects of plastic, synthetic, and cotton plant bed covers on seedling production and field performance of flue-cured tobacco were studied over a 4-year period. Results from 16 on-farm tests showed that perforated plastic and synthetic covers were more effective than cotton in the modification of the environment for transplant production. Even though no significant differences were obtained among the different covers for total plant stand, seedlings emerged faster and reached transplant size sooner under perforated plastic and synthetic covers when compared with cotton.

The field performance of flue-cured tobacco transplants produced under plastic and synthetic covers was compared to that of transplants produced under cotton in 1974-1977 at the Southern Piedmont Ctr., Blackstone, Va. Transplants of uniform size from each cover type were transferred to the field on the same date. With the exception of transplants produced under solid plastic in 1974, where yield, plant height, and days to flower were reduced, no differences in yield, quality, agronomic measurements or chemical constituents were found in comparisons involving the plant bed covers. Therefore, under the conditions of these tests, it was concluded that the use of perforated plastic and synthetic plant bed covers did not change the potential field productivity of flue-cured tobacco in comparison with cotton covers.

MANAGEMENT FACTORS AFFECTING PUBERTY AND LIBIDO IN BOARS. H. R. Thomas, H. G. Kattesh† J. W. Knight† F. C. Gwazdauskas, T. N. Meacham and E. T. Kornegay. Depts. of Animal Science and Dairy Science, VPI&SU, Blacksburg, VA 24061 and Suffolk, VA 23437

A total of 116 purebred and crossbred boars were evaluated for sexual behavior in two separate experiments. One study examined the effects of housing (outdoors on dirt vs confinement on concrete) and system of rearing (single vs group) on age at puberty and expression of libido. Boars housed on dirt and reared in groups reached puberty earlier ( $P < .05$ ) and had higher libido scores ( $P < .01$ ) than other treatment groups. A second study examined the effects of rearing boars in all male groups or with contemporary pre-pubertal females and found that age of puberty in boars was not significantly ( $P > .10$ ) different between rearing groups. However, it was found that boars reared without females subsequently attained a higher libido score ( $P < .05$ ). A higher incidence of lameness was seen in boars housed on concrete regardless of rearing category.

EFFECTS OF APPLIED STRESS ON ENDOCRINOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF SWINE: I. EFFECTS ON GESTATING SOWS. H. G. Kattesh† F. C. Gwazdauskas, J. W. Knight† E. T. Kornegay and H. R. Thomas. Depts. of Animal Science and Dairy Science, VPI&SU, Blacksburg, VA 24061 and Suffolk, VA 23437

Eight sows were subjected to applied heat ( $\bar{X}$  temperature =  $30.7^\circ\text{C}$ ) and crowding ( $.9\text{m}^2/\text{sow}$ ) stress (S) during mid-gestation (approximately days 32-82). Twelve sows were housed in outside dirt lots as controls (C). Blood samples were obtained via vena cava puncture from all sows on days -1, 0, 1, 2, 12, 13, 48 and 49 of treatment. A significant ( $P < .05$ ) reduction in corticoid (Cort.) concentration occurred in S sows by day 2 of treatment. A curvilinear time relationship was found in S but not in C sows. Corticosteroid binding globulin binding capacity for S sows was significantly ( $P < .01$ ) reduced by day 12 of treatment. No significant ( $P > .05$ ) differences due to treatment or time were found in the affinity of cortisol to bind to corticosteroid binding globulin. Gestation length was significantly ( $P < .01$ ) reduced in S vs C sows. There were no significant ( $P > .10$ ) differences in reproductive performance between S and C sows.

EFFECTS OF APPLIED STRESS ON ENDOCRINOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF SWINE: II. EFFECTS ON GESTATING GILTS. J. W. Knight† H. G. Kattesh† F. C. Gwazdauskas, E. T. Kornegay and H. R. Thomas. Depts. of Animal Science and Dairy Science, VPI&SU, Blacksburg, VA 24061 and Suffolk, VA 23437

During mid-gestation (days 21-71), 12 gilts were subjected to applied heat ( $\bar{X}$  temperature =  $33.5^\circ\text{C}$ ) and crowding ( $.9\text{m}^2/\text{gilt}$ ) stress. Eleven gilts, serving as controls, were housed outdoors and subjected to normal ambient temperature. Blood samples were taken via vena cava puncture at 20, 21, 22, 26, 30  $\pm$  1, 50  $\pm$  1, 71, 86  $\pm$  3 and 111  $\pm$  1 days of gestation. Corticoid (Cort.) concentrations were significantly greater ( $P < .01$ ) in control (C) vs stressed (S) gilts at all stages of gestation. There was an initial depression of basal Cort. levels in the S gilts but this depression was not maintained. From day 9 of treatment (day 30 of gestation) until the end of treatment, S gilts had significantly ( $P < .01$ ) lower corticosteroid binding globulin binding capacities than did C gilts. S gilts had significantly ( $P < .05$ ) lower mean association constants ( $K_a$ ) at days 22 and 30 of gestation compared to the C gilts.  $K_a$  values from days 1-50 in S gilts were significantly ( $P < .05$ ) lower than the pre-treatment value. No significant ( $P < .10$ ) differences were found between treatments for any measure of reproductive performance.

INFLUENCE OF SEX AND GROWTH RATE ON THE CALCIUM AND PHOSPHORUS REQUIREMENT OF MARKET HOGS. E. T. Kornegay and H. R. Thomas, Tidewater research and Continuing Education Center, VPI & SU, Suffolk, VA 23437.

In trial 1, 192 crossbred pigs with an avg wt of 23 kg were assigned by sex (barrows and gilts) and growth rate from birth (fast to slow) to the following dietary Ca and P combinations: 1) NRC Ca and P, 2) 25% higher than NRC Ca and P, 3) NRC Ca and 25% higher than NRC P, 4) NRC Ca and 25% lower than NRC P. Protein (16% to 14%) and Ca and P levels were lowered when avg was 45 kg. Barrows ate more, grew faster and were slightly less efficient than gilts. Avg daily gain and feed efficiency were poorest for pigs fed diet 4 with no difference between the other diets. Feed intake was similar for all diets. Although differences were small, pigs with the fastest growth rate from birth to 23 kg ate slightly more and grew slightly faster with no difference in feed efficiency. Feet and leg, pad and soundness scores were not influenced by any of the diets. Serum P level and metacarpal breaking strength and bone ash were lowest for pigs fed diet 4 with no difference between the other diets.

In trial 2, 144 pigs with an avg wt of 36 kg were randomly assigned to pens (equal male and female) and fed diets containing: 1) NRC Ca and P, 2) 25% higher than NRC Ca and P, 3) 50% higher than NRC Ca and P. Avg daily gain, feed intake, feed efficiency and soundness scores were not influenced by any of the diets. NRC Ca and P recommendations appear to be adequate.

INTERRELATIONSHIPS AMONG PERFORMANCE, SOUNDNESS, BONE AND BLOOD PARAMETERS IN GROWING AND FINISHING SWINE. E. T. Kornegay, H. R. Thomas and K. H. Hinkelmann, Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061

Correlation coefficients adjusted for parameters in the statistical model (sex, growth rate, dietary treatments and interactions) were made for all combinations of the following: average daily weight gain from birth to 23 kg (ADGB); average daily gain (ADG), average daily feed intake (ADFI), feed per gain (F/G) from 23 to 103 kg; pad (PS) and committee (CS) scores at 103 kg; metacarpal breaking strength (BKST) and ash (BASH) for barrows only; serum calcium (SCa) and phosphorus (SP) levels. ADGB had no influence on any of the parameters measured. There appeared to be no relationship between growth rate, soundness and bone parameters. Soundness, blood and bone parameters were unrelated with the exception of a very low positive correlation between PS and BKST ( $r = .23$ ,  $p .05$ ) and between SCa and CS ( $-.28$ ,  $p .05$ ). Pigs that grew the fastest ate the most feed ( $r = .85$ ,  $p .01$ ) and those that ate the most had the highest F/G ( $r = .67$ ,  $p .05$ ). BKST was positively related to BASH ( $r = .44$ ,  $p .001$ ). There was a low correlation ( $.28$ ,  $p .01$ ) between ADG and SP. In barrows ADFI was negatively correlated ( $-.89$ ,  $p .05$ ) with BASH and F/G was negatively correlated with BKST ( $-.88$ ,  $p .05$ ) and BASH ( $-.86$ ,  $p .05$ ).



APPLICATION OF SOLAR DRYING TO PEANUTS IN VIRGINIA. A. J. Lambert\* and D.H. Vaughan, Dept. of Agricultural Engineering, VPI&SU, Blacksburg, VA 24061.

In cooperation with a farmer in Greensville County, an integrated solar collector-peanut drying facility was built and tested (Oct.-Nov. 1977). As a part of the drying structure the solar collector faced south with 1325 sq ft at 22.60 and 364 sq ft at 90°, both from horizontal. The collector consisted of 0.037" 5V fiberglass panels 1" above a metal lath matrix (1/2" expanded to 1-1/2") and this was 4" above a black surface of 5/8" plywood. Approximately 3.5 cfm of air was drawn over the surface.

Solar radiation, LP gas usage, electricity consumption, tons of peanuts dried, and temperatures at 24 locations throughout the facility were recorded. Of the 170 Btu/ft<sup>2</sup> of solar radiation which was available (recorded on a horizontal surface) on October 20, a typical sunny day, 3,001,000 Btu were collected. The efficiency of the collected varied from 23-42% during the day from 10 a.m. to 4 p.m. For operation of the facility for this day, equivalent savings were 30 gallons of LP gas. For this level of operation over a 60-day period with \$1.50/ft<sup>2</sup> additional cost for the collector, the facility would pay for itself in 3-1/2 years. Since some days were cloudy and this amount of radiation was not always available, the payback is estimated to be 5-6 years. (Acknowledgments: Appreciation is expressed to W. B. Robinson, Jr. and Son, farmer cooperators and B. L. Flippin, Extension Agent.)

THE ECONOMIC IMPACT OF THE SOUTHERN PINE BEETLE ON WILDLIFE HABITAT AND POPULATIONS. J. D. Maine\*, and W. A. Leuschner, Dept. of Forestry and Forest Products, VPI & SU, Blacksburg, VA. 24061

One of the lesser known effects of the Southern Pine Beetle (*Dendroctonus frontalis*, Zimm.) (SPB), the most important timber-destroying insect in the south, is its impact on wildlife habitat and populations. SPB spots provide benefits to wildlife similar to those provided by timber harvest. SPB spots, in general, have a higher quality and quantity of wildlife food and cover. In addition, they add significantly to the interspersed of a forest stand which is expressed in an edge effect. This latter feature is particularly important when SPB spots occur in large areas of loblolly pine (*Pinus taeda*) monocultures. In this manner, SPB spots can increase a forest stand's carrying capacity for deer, rabbits, quail, woodpeckers, and other wildlife species, while only limiting the carrying capacity of a select few. Hence, a decrease in wildlife habitat and populations would be a cost of SPB control measures. Any decision concerning the implementation of SPB control measures should weigh all the known benefits and costs, not only those benefits and cost which are readily quantifiable. It is then possible that an area promising only marginal returns from SPB control would become uneconomical. (Funded by CSRS Project 804-15-1).

BEHAVIOR AND DISEASE RESISTANCE IN DWARF AND NONDWARF CHICKENS. J. M. Mauldin, W. B. Gross, and P. B. Siegel, VPI&SU, Blacksburg, VA 24061.

Investigated were several behavioral and physiological traits associated with the adaptability of dwarf and non-dwarf laying hens in populations of White Plymouth Rocks that had undergone selection for high (HW) and for low (LW) juvenile body weight. Data were obtained for "fear", head shaking, antibody titers to sheep red blood cells, plasma corticosterone titers, and resistance to *E. coli* infection for two generations of laying hens that were maintained in single wire cages. Significantly greater "fear" was noted in the LW than in the HW line and in dwarf than in normal pullets. Head shaking was significantly greater for normal than for dwarf pullets in both lines in one generation, while in the other generation the difference was significant in the LW line only. In both generations antibody titers to sheep red blood cells were greater in dwarf than in normal pullets from the HW line while no significant differences were noted between genotypes in the LW line. Percentages of mortality plus heart lesions, air sac lesions, and abnormal droppings to an *E. coli* challenge were greater in the HW line than in the LW line in one generation and less in the other. The inconsistency between generations may be explained by differences in the disease histories of individuals in the particular generation.

SEMEN HANDLING AND STORAGE EVALUATION. J. A. Lineweaver, F. C. Gwazdauskas and R. G. Saacke\*, Dept. of Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

An estimated 700 on-the-farm frozen semen storage tanks are in use on Virginia farms. When strict handling procedures are not followed the quality of stored semen can decrease to a point where serious conception problems arise. "Test canes" of semen have been prepared to evaluate semen handling techniques and storage tank stability. This semen was diluted in egg yolk-citrate and packaged in French straws at 60 x 10<sup>6</sup> sperm/ml. A special blue straw color was used and the top of the cane printed "Test" to differentiate this special semen. A total of 10 straws were used on each "check cane" and double decked with five straws on each deck. The top deck serves as a monitor for handling techniques while the bottom deck is a monitor for tank stability. Semen samples are scored for motility and intact acrosomes at 0, 2 and 4 hours post thaw. After four hours of incubation at 37°C, percent intact acrosome readings of more than 60, 40 to 60, 20 to 40 and below 20 are reported as excellent quality, normal quality, potentially injured and not recommended for use, respectively. After six months of storage, test canes in 24 farm tanks have not changed in quality. As of January 1, 1978, a total of 294 samples of semen other than test canes from farm tanks had been evaluated. The percent of samples in the excellent quality, normal quality, potentially injured and not recommended for use classes were 12, 47, 31 and 10, respectively.

EFFECTS OF SELECTED INSECTICIDES ON THE POTATO LEAFHOPPER (*EMPOASCA FABAE HARRIS*) AND ENTOMOPHAGOUS INSECTS IN ALFALFA. D. G. Martinez\*, D. E. Simonet, and R. L. Pienkowski, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

A two year old stand of Saranac AR alfalfa in Montgomery County, Virginia was used to assess insecticide efficacy on potato leafhoppers and effects on entomophagous species of arthropods. Eight treatments with an untreated check, replicated four times, were arranged in a randomized block design. Samples were taken 48 hr, 1 wk, and 2 wk after treatment using a 15" sweep net. Insect counts were transformed to Log (X+1) for analysis. Yield samples 3' X 20' per plot, were taken with a flail forage harvester. Green weight and percent dry matter was determined.

Leafhopper populations were not at economically damaging levels when the treatments were applied. Carbofuran methidathion controlled leafhoppers for up to 2 weeks after treatment. No significant differences were observed for yields as percent dry matter. Mirids and *orizus* spp. appear to be the most tolerant of the beneficial insects treated. Carbaryl did not reduce coccinellid population. No significant differences were observed on the effects of the insecticides on chrysopids.

THE BENEFICIAL INSECT QUARANTINE LABORATORY AT VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY. L. T. Kok and T. J. McAvoy\*, Dept. of Entomology, VPI & SU, Blacksburg, VA. 24061

The beneficial insect quarantine laboratory at VPI & SU was officially approved as a receiving station by the Animal Plant Health Inspection Service of the U.S.D.A. in February 1973. Located at the University's Prices Fork Road research complex about 5 miles off campus, it is one of only three such facilities in the country under University control. This facility was set up to enable VPI to directly receive foreign insects for quarantine testing in its biological control program. Basic to the biocontrol concept is the selection and screening of potentially effective exotic agents for field release at the site of the problem pest. Current projects involve the screening of beneficial phytophagous insects for *Carduus thistle* control to determine their safety prior to introduction into the country. Since the test insects must be kept under strict supervision, the building is restricted to authorized personnel only. Special features of the self-contained, centrally air-conditioned, single story building (52'x26') include an airlock at each end of the central corridor from which the 7 rooms open. The corridor and air locks have UV lighting which trap photo-positive insects. All windows have double glass panes permanently sealed and protected by wire-screening. Vents of air-conditioning ducts are covered with 100 mesh copper wire-screen carefully soldered to confine very small organisms,



SEASONAL EFFICIENCY OF THE LIMB BEATING SAMPLING TECHNIQUE FOR ESTIMATING SPIDER POPULATIONS FROM APPLE TREES. J. P. McCaffrey and R. L. Horsburgh. Shenandoah Valley Res. Sta., Va. Polytechnic Inst. & State Univ., Steeles Tavern, VA 24476.

The seasonal efficiency of the limb beating technique for estimating spider populations from Golden Delicious apple trees was evaluated twice monthly May-August, 1977. The peripheral linear meter of limb was the sample unit employed throughout the investigation. Sample limbs were tapped and dislodged spiders were caught on a 1 m<sup>2</sup> muslin covered tray. Immediately after being tapped, each limb was enclosed in a plastic bag, cut from the tree, and examined for spiders that were not dislodged. Those spiders found remaining on the limb together with those previously dislodged constituted total capture. The percent efficiency of capture for the limb beating technique was high for the salticids, phlo-dromids, and total spiders. No significant differences were found between the limb beating and total capture population estimates at any sample date for the spider groups mentioned.

THE USE OF HYPOVIRULENT CULTURES OF *Endothia parasitica* FOR THE BIOLOGICAL CONTROL OF CHESTNUT BLIGHT IN YOUNG EVEN-AGED STANDS. T. J. McEvoy and G. J. Griffin. Dept. of For. and For. Prod. and Dept. of Plant Phys. and Path., respectively, Va. Polytech. Inst., Blacksburg, VA 24061

In June 1977, 32 sprouts of American chestnut (*Castanea dentata*) were selected in an 8 year old, even-aged stand on the Jefferson National Forest in Craig County, Virginia. The trees were tagged, measured by diameter class, and inspected for natural cankers. Various combinations of inoculations were performed with 2 different isolates of *E. parasitica*. One of the isolates (Ep 43) is a European derived hypovirulent strain. The other (PC) is a known virulent strain obtained locally (Poverty Creek). Natural cankers were inoculated 1.0 cm from the margin with an average 4, 0.7 cm diameter inoculum cores of Ep 43 utilizing a cork borer. Other inoculations involved either Ep 43 and PC alone or in combination. After 65 and 310 days subsequent canker growth was measured. There were no significant differences between mean growth of control and treated cankers after 65 and 310 days, although induced cankers of Ep 43 alone were significantly smaller after the treatment periods than of PC alone. The results indicate a possible incompatibility between European derived Ep 43 and native virulent strains of *E. parasitica*.

ESTIMATION OF MALATHION RESIDUES IN SOME HOME GARDEN VEGETABLES. N. K. Narain\*, V. E. Melchor, and C. C. Lewis\*. Dept. of Chemistry and USDA-SEA/CR Pesticide Research Project, Virginia State College, Petersburg, Va. 23803

Residues of malathion (Diethyl mercaptosuccinates, s-ester with o, o-dimethyl phosphorodithiate), were determined in the fruit and foliage of cabbage (Stonehead), cucumber (Victory), garden bush beans (Contender), okra (Emerald Green), pepper (Keystone Resistant Giant), squash (Table King), and tomato (Better Boy) by a gas chromatographic (GLC equipped with a FPD detector) method. Residues at harvest averaged the following range: cabbage (head, 0-0.05 ppm), cucumber (foliage, 0 ppm; fruit, 0.03-0.19 ppm), garden bush beans (fruit, 0 ppm), okra (foliage, 0 ppm; fruit, 0.03 ppm), pepper (foliage, 0-0.04 ppm; fruit, 0 ppm), squash (foliage, 0-0.02 ppm; fruit, 0 ppm), and tomato (foliage, 0-0.03 ppm, green fruit, 0 ppm; mature fruit, 0 ppm).

Residues levels on these vegetables sprayed with malathion (2.75 lb ai/acre) were well below the tolerance limit of 8 ppm established by EPA. On the average 90% of the pesticide was recovered in the fortification studies. (Aided by a grant (616-15-137) from USDA-SEA/CR).

HOST RANGE OF *GLOBODERA SOLANACEARUM*, G. VIRGINIAE, G. TABACUM, G. "MEXICANA" AND G. ROSTOCHIENSIS ON SELECTED PLANTS OF THE CHENOPODIACEAE, CRUCIFERAE, LEGUMINOSAE AND SOLANACEAE. L. I. Miller. Dept. of Plant Path. & Phys., V.P.I. & S.U., Blacksburg, Va. 24061

The ability of type locality isolates of *Globodera solanacearum* (SOL), *G. virginiae* (VIR), *G. tabacum* (TAB), *G. "mexicana"* (MEX) and the Ramero isolate of *G. rostochiensis* (ROS) from Mexico to develop egg-bearing females was tested on the following plants: *Solanum dulcamara* (bittersweet nightshade), *S. tuberosum* ('Pontiac' potato), *Nicotiana tabacum* ('NC 95' tobacco), *Lycopersicon esculentum* ('Pearson A 1' tomato), *Capsicum frutescens* ('California Wonder' pepper), *Glycine max* ('Lee' soybean), *Arachis hypogaea* ('Floriant' peanut), *Brassica oleracea* var. *oleracea* ('Chieftan Drumhead' cabbage) and *Beta vulgaris* ('US 75' sugar beet). Inoculum of 25 cysts of each of the 5 nematode species was added to cyst-free soil in 100mm pots. A single seedling or seed piece was transplanted or planted to each pot, and after 7 weeks roots were examined for the presence of fifth-stage females. The experiment was conducted in Virginia, except for the tests with ROS in Mexico. No females were formed by any of the nematode species on pepper, soybean, peanut, cabbage and sugar beet. Numerous females of only ROS were formed on potato. Medium to numerous females were formed on bittersweet nightshade, tobacco and tomato by SOL, VIR, TAB, MEX and ROS, except that only a few females were formed by VIR on tobacco.

CHANGES IN POSTPARTUM PROGESTERONE IN LACTATING DAIRY COWS. C. E. Milliron\*, D. L. Aalseth\* and F. C. Gwazdauskas. Dept. of Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A 10 ml milk sample was collected from fifteen lactating Holstein dairy cows at the daytime milking (1100 to 1300 hours), weekly, from parturition to first breeding. An additional milk sample was collected at 21 days post breeding. Milk progesterone (P) concentrations were determined by radioimmunoassay techniques. Thirty-two heats were detected in 13 cows during the postpartum period including first breeding. Estrus P was  $.81 \pm .65$  ng/ml milk ( $\bar{x} \pm$  SD),  $n=32$ . Four P concentrations at estrus were greater than 1.5 ng/ml milk ( $\bar{x} \pm$  one SD) and thus deleted from the data. Thus estrus P was  $.60 \pm .24$  ng/ml ( $n=28$ ). In general, milk progesterone fluctuated in a cyclic pattern during the early postpartum period. Eight cows prior to breeding averaged 4.0 ng/ml P for 1.6 weeks between pre-breeding heats. The appearance of P above 2.1 ng/ml ( $>.81 \pm 2$  SD) occurred in 13 cows and averaged 3.7 ng/ml at 4.5 weeks into the lactation. Average number of days to first observed heat was 47. Thus it appears that ovarian function can be monitored by milk P in the postpartum period of the dairy cow.

ESTIMATES OF AVAILABLE NUTRIENTS IN THE SOIL PROFILES OF FORESTED RIDGE AND VALLEY SITES. R. A. Morin\*, J. D. Gregory, and D. W. Smith\*. Dept. of Forestry and Forest Products, Va. Polytechnic Inst., Blacksburg, VA 24061

Detailed analyses were made of total N and extractable P, K, Ca, and Mg concentrations throughout the soil profile on six different forested sites in the Ridge and Valley area of Virginia. Soil samples were taken at every 10 cm depth, starting at the surface and going down to parent material. Considerable differences in nutrient concentrations were found both between depths at a given site, and between sites. The concentration of total N ranged from 173 to 2.258 ppm. The concentration of extractable P ranged from 0.20 to 5.52 ppm. The extractable K concentration ranged from 6.66 to 160.89 ppm. The extractable Ca concentration ranged from 1.68 to 55.76 ppm. The concentration of extractable Mg ranged from 0.40 to 79.92 ppm.



BLANCHABILITY OF VIRGINIA TYPE PEANUT LINES. R. Walton Mazingo. Tidewater Res. and Continuing Education Ctr., Suffolk, Va. 23437

Extra large and medium grade peanuts of two released varieties and eighteen advanced breeding lines were evaluated for blanching quality. Peanuts from the early and late diggings at Suffolk, Virginia and the late digging at Martin County, North Carolina were used to determine the percentage of kernels not blanched, partially blanched, whole blanched and splits blanched.

Generally, advanced breeding lines with Florigiant in their pedigree blanched better than lines which had NC 5 as one parent. The lines with the Florigiant background had a higher whole blanched percentage and lower not blanched percentage for both the extra large and medium grades. A three-year average of the two parent lines Florigiant and NC 5 showed Florigiant superior to NC 5 by being statistically different with a higher percentage of whole blanched and a lower percentage of not blanched and partially blanched. There was no statistical difference for the percentage of splits blanched.

The extra large grade blanched better than the mediums with the mean of all twenty entries being 62.2 percent whole blanched for extra large compared to 52.5 percent for mediums. The mediums had 29.1 percent not blanched compared to 20.6 percent for the extra large grade.

THE USE OF DOUBLE AND TRIPLE DECKS TO INCREASE NURSERY DENSITY. B. O. Ogunbameru\*, E. T. Kornegay, K. E. Bryant\*, K. H. Hinkelmann, J. W. Knight\* and E. R. Collins, Jr. Depts. of Animal Science, and Agricultural Engineering and Statistics, VPI&SU, Blacksburg, Virginia 24061

Two 5-week trials using 128 pigs per trial compared the performance of pigs weaned at 26 days of age (6.8 kg average initial weight) reared in single (SD), bottom (BD), and top (TD) decks. All pigs had .28 m<sup>2</sup> floor space. The combined data, showed no significant difference in performance between the pigs reared in SD, BD and TD: Average daily gain, (ADC) .31, .30 and .32 kg; average daily feed intake (ADFI) .59, .56 and .59 kg; feed per gain (F/C) 1.91, 1.88 and 1.85, respectively. Three additional 5-week trials using 36 pigs each in two trials and 24 pigs in the other trial compared the performance of pigs weaned at 22 days of age (5.1 kg average initial weight) reared in bottom (BD) middle (MD) and top (TD) decks. There were 4 cages (1.2 x 1.2 m) per deck per trial involving 3 pigs per cage in two trials and 2 pigs per cage in the other trial. Combined data revealed no significant difference in performance between pigs reared in BD, MD and TD: ADC .31, .31 and .35 kg; ADFI .47, .48 and .52 kg; F/C 1.51, 1.51 and 1.51, respectively. In all trials urine and feces were allowed to pass thru the pen or cages to the pit or floor below the bottom pen or cage. Feed and water were offered free choice in all trials. In general, pigs housed on all decks performed well with no apparent effect on the health, appearance and behavior of the pigs.

EVALUATION OF A FEED FLAVOR IN LACTATION AND STARTER DIETS TO STIMULATE THE INTAKE OF WEANED PIGS. B. O. Ogunbameru\*, E. T. Kornegay, K. E. Bryant\*, K. H. Hinkelmann and J. W. Knight\*. Dept. of Animal Science, VPI&SU, Blacksburg, Virginia 24061

In two 5-week trials, 128 pigs weaned from sows fed flavored lactation diet (SF), 27 days of age, 7.0 kg average initial weight (AIW), and 128 pigs from sows fed nonflavored lactation diet (SNF), 26 days of age, 6.5 kg AIW, were used to evaluate the use of a feed flavor in the lactation diet to stimulate the intake of weaned pigs. All pigs were fed a flavored starter diet *ad libitum*. Combined data for both trials revealed no significant difference in performance between the SF and SNF pigs: Average daily gain (ADC) .32 and .30 kg; average daily feed intake (ADFI) .59 and .58 kg; feed/gain (F/C) 1.85 and 1.91, respectively. Three additional 5-week trials, 48 pigs weaned from sows fed SF diets, 22 days of age, 11.1 kg AIW, and 48 pigs weaned from sows fed SNF diets, 22 days of age, 11.3 kg AIW, were used to further evaluate the use of a feed flavor in the lactation diet to stimulate the intake of weaned pigs. Half of the SF and half of the SNF weaned pigs were fed a flavored starter diet (PF) while the other half were fed a nonflavored starter diet (PNF). Diets were offered *ad libitum*. Combined data for all three trials revealed that neither the maternal nor pig dietary treatment had a significant effect on the SF, SNF, PF and PNF pigs: ADC .32, .33, .33 and .32 kg; ADFI .49, .49, .50 and .49 kg; F/C 1.52, 1.52, 1.51 and 1.53, respectively.

MANGANESE RELEASED FROM HARDWOOD BARK, WHICH IS USED AS A GROWING MEDIUM FOR PLANTS. D. C. Milbocker\*, Va. Truck & Ornamentals Res. Station, Norfolk, Va. 23501, and R. A. Palmer, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

As the price of peat used for amending container media increases, substitutes for peat are being used more frequently. Among nurserymen, pine bark has been accepted with success. Hardwood bark is equally plentiful, but has not been readily accepted. Some plants grown in hardwood bark become chlorotic, and others grow slowly. Chlorosis of the type observed is the symptom of iron deficiency, but the analysis of hardwood bark has shown that sufficient iron is present. The results described in this paper show the relationship between plant growth and the iron and manganese content of the leachate from container media. Analysis of the leachate from media containing large proportions of hardwood bark shows that manganese is preferentially leached from the bark. Readily available manganese can render iron unavailable to the plant, which produces chlorosis and growth suppression. The addition of iron corrected the chlorosis, and restored normal growth rates.

SEMEN PREPARATION AT LOW ENVIRONMENTAL TEMPERATURES.

J. A. Lineaver, J. E. Parks\*, J. L. Waugh\*, R. C. Saacke\*, and F. C. Cwazdauskas. Dept. of Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Bovine semen, packaged in straws and thawed at 35°C for artificial insemination (A.I.), causes concern when environmental temperatures are below 15°C. A thermoregulated semen and A.I. equipment carrier was developed for storage of A.I. guns and sheathes and for holding semen (post-thaw) at 35°C between thawing and insemination. Temperature inside the 7.7 x 56 cm cylindrical chamber was controlled by a built-in solid state thermostat. A .5 ml French straw containing a thermo-couple was loaded into a stainless steel inseminating gun. Temperature changes were monitored inside the French straw from thawing through preparation of the A.I. gun and during a holding period of at least 20 min. after preparation at environmental temperatures of 21°, 4° and -16°C. At environmental temperatures of 21, 4 and -16°C, temperature decreases of 5.9, 15.6 and 22.3°C, respectively, occurred when the A.I. equipment was kept at that environmental temperature. Temperature decreases of 3, 14.2 and 16.8°C occurred when the gun was warmed at 35°C before loading. During a holding period of 10 min and a starting temperature of 35°C the equipment holder allowed temperature decreases of .7, 1.5 and 4.8°C at environmental temperatures of 21, 4 and -16°C. The decrease in temperature inside the straws in the unprotected gun at 10 min after exposure to 21 and 4°C were 6.7 and 28.2°C, respectively. At -16°C the temperature decrease was 44.8°C in 4 min.

POPULATION DYNAMICS OF SOME PREDATORS AND THEIR PREY IN VIRGINIA APPLE ORCHARDS. M. P. Parrella, J. P. McCaffrey and R. L. Horsburgh, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Shenandoah Valley Research Station, Steeles Tavern, VA 24476.

Apple orchards in central Virginia were sampled twice monthly from April - Sept., 1977 for predators and their associated prey. Primary consideration was given to the following pests: *Panonychus ulmi* (Koch), *Aculus schlechtendali* (Nalepa), *Aphis pomi* DeCreer, *A. citricola* van der Coot, *Dysaphis plataginea* (Passerini), *Platynota flavedana* Clemens, *P. idaeusalis* (Walker) and *Argyrotaenia velutinana* (Walker). The insect predators collected from the trees were *Leptothrips mali* (Fitch), *Haplothrips sub-tillissimus* (Haliday), *Orius insidiosus* (Say), *Deraeocoris nebulosus* (Uhler) *Chrysopa* spp., *Plagiognathus* spp., *Hyaloides* spp. and *Stethorus punctum* Le Conte. Five orchards under different spray programs were sampled so that the effects of various chemical treatments on the predator-prey complex could be assessed. The commercial programs utilizing Imidan, Phosalone and Azinphosmethyl yielded fewer predators than did two integrated programs (reduced rates) of Phosalone and Azinphosmethyl. The severity of many of the above pests was reduced under these integrated programs. The most abundant predator in all orchards was *L. mali* which in many cases seemed to respond to the presence of *A. schlechtendali*.

CHANGES IN MECHANICAL ANALYSIS RESULTS ON SOILS SUBJECTED TO PROLONGED SOAKING IN CALGON SOLUTION. C. D. Peacock, Jr., A. C. Blackburn, and J. L. Richardson. Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The Bouyoucos 2-hour hydrometer method was used to test changes in particle size analysis results when subjected to prolonged soaking in calgon solution. Two treatments were evaluated using samples, with three repetitions each, from the A horizon and control section of the B or C horizons of five soil series with varying family and order placements. Soil, treatments, and horizons were used in an ANOVA fixed effect model to determine the significance of the means at the 95% confidence level. The five soils were found to be significantly different, with varying degrees of significance for horizons and treatments. Results obtained by prolonged soaking of particle size analysis samples should be viewed with caution since some significant differences were observed.

DISPERSAL ACTIVITY OF THE GERMAN COCKROACH (*BLATTELLA GERMANICA* (L.)) UNDER FIELD CONDITIONS. P. K. Powell\*, R. C. Akers\*. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

The dispersal activity of German cockroaches within multiple-unit, urban dwellings was investigated. Genetically marked, nymphal and adult male cockroaches were released in the basements of several apartment buildings in Roanoke, Virginia during 1977-1978. Dispersal activity was monitored by the use of three fruit-baited traps per apartment; traps were collected weekly for ten weeks.

During the first four weeks marked cockroaches were recaptured in successive apartments adjacent to the release site. The data indicate that under field conditions marked, adult and nymphal male cockroaches will actively disperse throughout a large existing population.

RADIAL GROWTH OF CHESTNUT OAK ON ADVERSE SITES. H. M. Rauscher\*, D. W. Smith\*, and J. D. Gregory. Dept. of Forestry and Forest Products, Va. Polytechnic Inst., Blacksburg, VA 24061

During the 1976 growing season, three chestnut oaks (*Quercus prinus* L.) were measured for daily radial growth. These trees were growing on a dry, nutrient poor Appalachian Mountain site in southwest Virginia. Daily radial growth was measured using a Fritts dendrograph and two Byran and Doolittle lag screw and bracket devices in conjunction with micro-calipers. Growth was defined as any increase in radial expansion greater than the largest previously recorded value.

The 1976 growing season for this site was from April 15-August 30. Radial growth occurred on 20% of the days in the growing season. Days tended to cluster in a sequence of growth days followed by a sequence of no-growth days. The average growth on a growth day was found to be 0.07 mm.

Multiple regression equations were developed for predicting radial growth for each tree. These equations were based on 27 climatic and water stress variables measured for each tree.

MOVEMENT AND CHANGES IN NITROGENOUS COMPOUNDS IN WET TILE DRAINED SOILS AS INFLUENCED BY SEPTIC EFFLUENT DISPOSAL. R. B. Reneau, Jr.

Changes in ammonium, nitrate and nitrite nitrogen concentrations were monitored in shallow ground waters between septic tank effluent disposal fields and a subsurface tile drainage system from September, 1974 to July, 1976. This was part of a study supported by the Virginia Department of Health, to determine movement and distribution of pollutants from septic tank effluents in wet tile drained soils. Soils studied were classified as Typic and Aeric Ochraqults. Sampling wells were placed at 152 and 456 cm from the disposal field and 152 cm on either side of the tile drainage system. Soil pedons sampled correspond with placement of sampling wells.

Nitrogenous components from the septic tank effluents underwent similar biochemical transformations in both the Typic and Aeric Ochraqult. Ammonium was present adjacent to the drainfield in concentrations ranging from 20 to 30 µg/ml and had decreased to <1 µg/ml at the remainder of the distances sampled while NO<sub>3</sub>-N increased with distance, reached a maximum, and then decreased. The NO<sub>3</sub>-N accumulation was seasonal with the highest concentrations present during periods of rising water tables. The NO<sub>3</sub>/Cl ratios showed that NO<sub>3</sub> accumulation reached a maximum at approximately 5 m and then decreased with increased distance. This indicated that NH<sub>4</sub> was nitrified and the NO<sub>3</sub> produced was subsequently denitrified to a large degree.

CONTROL OF THE CORN LEAF APHID (*RHOPALOSIPHUM MAIDES* (FITCH)) ON BARLEY (*HORDEUM VULGARE*). J. E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061, and Robert D. McLaughlin\*, Mobay Chemical Corp., Raleigh, NC 27604 respectively

Control of Corn Leaf Aphids on Barley, 1977: Barley was planted at the C. N. Brown farm Bedford County, Va. Sept. 20. Plots were 0.01 acres and replicated three times in a randomized complete block design. Insecticides were applied Nov. 1 using a backpack CO<sub>2</sub> pressurized sprayer with a three ft. boom.

Disyston 6E gave excellent control of aphids especially at the 1 lb. rate; and Croneton 4E at all rates gave better than 85% control.

There was no phytotoxicity observed at the time of final evaluation.

CONTROL OF THE FALL ARMYWORM (*SPODOPTERA FRUGIPERDA* (J. E. SMITH)) ON CORN (*ZEA MAYS* L. 'PIONEER 3147'). R. C. Akers\*, and J. E. Roberts, Sr. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Corn, Fall Armyworm Control, 1977: In a field test at Charlotte Court House, Virginia, five insecticides were tested to determine their efficacy in controlling fall armyworm on conventionally tilled corn. Evaluations of treatments were made 48 h after application by counting the number of live fall armyworms from the center 10.1 m row of each replicate. Percent control was calculated on untreated checks. All insecticides were compared to controls within the design.

Furadan 10G and Dyfonate 20G proved to be the most effective, while Dyfonate 10GK gave the poorest control. None of the tested insecticides were phytotoxic.



CONTROL OF ARMYWORMS (*PSEUDALETIA UNIPUNCTA* (HAWORTH)) ON BARLEY (*HORDEUM VULGARE* 'MCNAIR 601'). R. C. Akers\*, and J. E. Roberts, Sr. Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Barley, True Armyworm Control, 1977: In a field test at Tappahannock, Virginia, five insecticides were tested to determine their efficacy in armyworm control. Three replications of each treatment were applied to plots in a randomized block design. Evaluations of treatments were made 48 h after application by counting the total number of live larvae in five, randomly selected, one sq. ft. areas within each plot. Percent control was based on untreated checks.

CGA-15324, PennCap-M (®), and Sumithion 8E yielded the best results and were equally effective. Imidan 50W and Trithion 8E did not produce sufficient mortality. None of the insecticides were phytotoxic.

CONTROL OF LICE (*BOVICOLA BOVIS*, *LINOCNATHUS VITULI*, *SOLENOPTES CAPILLATUS*) ON BEEF CATTLE. R. C. Akers\*, and J. E. Roberts, Sr. Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

A test demonstration for control of lice on beef cattle was conducted in Smyth County, Virginia in March and April of 1977. The test compared TR302 pour-on against untreated checks.

Two rates of this chemical were applied - 5 ml/100 lb. body weight and 15 ml/100 lb. body weight at Bruce Harden Farm, Broadford, Virginia and Bill Price Farm, Marion, Virginia respectively. The cattle used for these tests were Hereford yearlings of mixed gender, weighing approximately 350 lbs. at Harden Farm and 500 lbs. at Price Farm. Four weeks after treatment was applied the 5 ml/100 lb. body weight was 87.3 percent effective and the 15 ml/100 lb. of body weight was 98.0 percent effective.

No adverse symptoms were observed in the cattle. In most cases, the pigment of the skin and general appearance of the treated cattle improved during the time of the tests.

CONTROLLING WEEDS IN CORN (*ZEAMAYS* L.) WITH THIOCARBAMATE HERBICIDES APPLIED WITH AND WITHOUT ANTIDOTES. E. G. Sagalar\* and C. L. Foy, Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, VA 24061

Controlling difficult weeds in corn (*Zea mays* L.) with thiocarbamate herbicides often causes severe injury to the crop. Twisting of the leaves, reduced growth, and death of the highly susceptible species are the common symptoms. To avoid or minimize injury to the corn crop, without reducing the efficiency of the herbicide from controlling the weeds, antidotes are used.

This experiment was conducted on Lodi loam soil (pH - 5.7, O.M. = 1.8%) at Blacksburg, Virginia, to determine the effects of several thiocarbamate herbicides, applied alone or in combination with an antidote, for weed control in selected susceptible corn cultivars. Results of this study indicated that high rates of EPTC (S-ethyl dipropylthiocarbamate) at 13.4 kg/ha; vernolate (S-propyl dipropylthiocarbamate) 13.4 kg/ha; and butylate (S-ethyl diisobutylthiocarbamate) 13.4 kg/ha, caused more injury to all the corn cultivars used, but provided more adequate season-long weed control than when only half these rates were used. However, where the same rates of applications were used in combination with the antidotes R-25788 (N,N-diallyl-2,2-dichloroacetamide) or R-29148 (2,2,5-trimethyl-N-(dichloroacetyloxazolidine) reduced injury symptoms were observed without loss of effectiveness in controlling the weeds.

INFLUENCE OF HERBICIDE ANTIDOTE N,N-DIALLYL-2,2-DICHLOROACETAMIDE (R-25788) IN PROTECTING CORN (*ZEAMAYS* L.) FROM EPTC INJURY. E. G. Sagalar\* and C. L. Foy, Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, VA 24061

Field and greenhouse experiments were conducted in 1976 and 1977 to determine the influence of herbicide antidote R-25788 (N,N-diallyl-2,2-dichloroacetamide) in protecting selected corn (*Zea mays* L.) hybrids from EPTC (S-ethyl dipropylthiocarbamate) injury. Pre-plant incorporated applications were made on the Othello fine sandy loam soil containing more than 3.0% organic matter and the Dothan sandy soil with less than 1.0% organic matter. Results of this study showed that treatments of EPTC at the rate of 6.7 kg/ha were 20 to 30% more toxic to the susceptible variety DeKalb XL55, XL22B, XL379, PX79, XL80A, G-4646 and RX94 under sandy and lower organic matter conditions than with fine sandy loam having more than 3.0% organic matter. The residual activity and adequacy of weed control was also more evident at lower organic conditions. These observations under field conditions were confirmed further with studies conducted in the greenhouse using the same types of soil.

The corn hybrid TXS114 was found highly tolerant to EPTC at 6.7 kg/ha at the two locations, while the other corn cultivars used, which normally were susceptible to EPTC applications, showed significant improvement in their stands without any observable symptoms of toxicity, when the antidote R-25788 was applied in combinations with EPTC.

BIOLOGICAL FACTORS AFFECTING THE PROPAGATION OF THE PUPAL PARASITE, *COCCYGMIMUS TURIONELLAE*. P. B. Schultz and L. T. Kok. Virginia Truck & Ornamentals Research Station Norfolk, Va. 23501 and Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061, respectively.

*Coccygmimus turionellae* (L.) (Hymen: Ichneumonidae), a polyphagous pupal parasite was first imported and liberated in the New England states against the gypsy moth in 1906-09. In 1972, it was imported from India for release in areas of gypsy moth infestations. Biological factors affecting the rearing of *C. turionellae* on wax moth pupae were examined to determine the optimum conditions for its mass propagation. The most critical factors were the parasite: host (P/H) ratio, and duration of exposure of host to the parasite. In a study involving seven P/H ratios and three exposure times, optimum parasite emergence occurred with a ratio of .4 or .5 at 24-h exposure, and with a ratio of .1 at 72-h exposure. Production of *C. turionellae* could be increased by retarding pupal development of the wax moth. Decreasing the storage temperature of wax moth pupae from 32° to 27°C extended the duration of its suitability for parasitism from two to seven days. Prompt removal of wax moth pupae from the 32°C rearing temperature was found to increase the emergence of *C. turionellae*. Mass rearing was unaffected by the age of *C. turionellae*, but a significant drop in fecundity did occur after five years of laboratory rearing. The 21% reduction in parasite progeny emergence between 1976 and 1977 could be attributed to genetic decay within the colony.

A CONCEPTUAL MODEL TO DEFINE THE EFFECT OF AGRICULTURAL LAND MANAGEMENT PRACTICES ON THE QUANTITY AND QUALITY OF STORM RUNOFF. B. B. Ross\*, U. D. Shanholtz, Dept. of Agricultural Engr., and D. N. Contractor\*, Dept. of Civil Engr., VPI&SU, Blacksburg, VA 24061.

A finite element computer-based watershed model structure has been developed with sufficient resolution to delineate land use units and assimilate their characteristics to provide a rational assessment of their effect on the quantity of storm runoff. This model conceptually provides a mechanism for identifying non-point source loading rates from specific agricultural practices and the linkage of loading rates from geographically distinct land use units to estimate the total impact on the quality of storm water at some downstream point.

Comparisons of simulated and recorded storm runoff in an unsaged context have been very encouraging. These results have provided the impetus to continue research towards the development of a system to describe the processes of detachment, transport and deposition of sediment from upland areas to receiving streams and through the primary drainage system. The flexibility of this modeling structure will be demonstrated by several numerical examples.

THE ECONOMIC IMPLICATIONS OF SOUTHERN PINE BEETLE ATTACKS UPON THE HYDROLOGIC COMPONENTS OF A FORESTED WATERSHED. D. G. Shore\* and W. A. Leuschner, Dept. of Forestry and Forest Products, VPI & SU, Blacksburg, VA 24061

The forested watershed affects the allocation of water among competing agents including vegetation, ground water storage, and the stream system. Pine mortality caused by the southern pine beetle (SPB) reduces the watershed's transpiring surface area allowing more water to enter the stream system and/or ground water storage. Changes in the amount of water entering the stream system and ground water storage may also change water quality, soil erosion rates, nutrient loss, and water temperatures. Empirical evidence supported by hydrologic simulation shows that reductions of greater than 20% in forested basal area will cause significant increases in water yield. Therefore, SPB control when water recharge rates are less than consumption may cause social costs if there is a reduction of water entering the stream system that would have otherwise been readily available for human use. (Funded by CSRS Research Agreement #680-15-3).

METHODOLOGY OF TWOSPOTTED SPIDER MITE CONTROL IN PEANUTS AND SECONDARY PEST INVOLVEMENT. J. C. Smith, Tidewater Research and Cont. Ed. Ctr., VPI & SU, Suffolk, Va. 23437.

Two experiments were established in 1977 to determine efficacy of candidate insecticides in controlling the two-spotted spider mite, *Tetranychus urticae* Koch, on peanut foliage. At one site, only spider mites occurred in sufficient numbers to be economically important. A second site had serious infestations of potatoe leafhoppers and corn earworms in addition to late developing spider mites. Preventative sprays of the effective acaricides Azodrin and Kelthane were effective in preventing the establishment of spider mite infestations. Also, Azodrin effectively controlled potatoe leafhoppers and corn earworms. When applied as soil-systemics at planting, Temik @ .5 lb AI/acre, Thimet @ 1.0, DiSyston @ 1.0 and Dacamox @ 2.0 controlled tobacco thrips and potatoe leafhoppers. The soil-applied systemics failed to control earworms, and infestations on Thimet-treated plots were worse than on untreated controls. Serious spider mite infestations developed at one site on plots treated with Sevin sprays and on spots with split applications of DiSyston. Split applications of Temik or layby (only) applications were nearly as effective as preventative sprays of Kelthane. Yields and values corresponded with spider mite counts or ratings at one site, but were complicated by potatoe leafhopper and corn earworm infestations at the other site.

MODELING SURVIVAL IN YOUNG NATURAL STANDS OF LOBLOLLY PINE WITH A WEIBULL DISTRIBUTION. G. L. Somers\*, R. G. Oderwald\*, W. R. Harms\*, O. G. Langdon\*. Dept. of Forestry and Forest Products, VPI & SU, Blacksburg, Va. 24061

A two-parameter Weibull distribution is used to closely approximate the survival distribution in young stands of loblolly pine. The study uses data from permanent plots supplied by the Southeastern Forest experiment Station going from age three through fourteen years. A total of twenty plots were thinned at age three, to five densities: 1M, 2M, 4M, 8M, and 16M trees per acre, with four plots at each density level. Maximum likelihood estimators are used to estimate the shape and scale parameters of the Weibull distribution, using age as the random variable. Two alternatives are compared for the value of the location parameter, age 3 and age 0 (this assumes no deaths before age 3). One minus the cumulative density function gives the percent survival at each age which is compared with the actual survival for each plot using the Kolmogorov goodness-of-fit test. All the plots show non-significant differences at the .05 level of significance.

FUNGAL ASSOCIATES OF TREES IN VIRGINIA. I. R. J. Stipes and M. K. Roane, Dept. Plant Pathol. & Physiol., VPI & SU, Blacksburg, VA 24061.

The following fungus-tree associations are reported for Virginia:

Polyporus cuticularis on Acer nigrum  
Ganoderma sessile on Acer rubrum  
Cryptodiaporthe castanea on Castanea dentata  
Anisogramma anomala on Corylus avellana  
Cenangium ferruginosum on Pinus thunbergii  
Adelopus gäumannii and Diplodia pinea on  
Pseudotsuga taxifolia  
Botryosphaeria dothidea and Cronartium ribicola on  
Pinus strobus  
Glomerella cingulata on Acer platanoides (first report)  
Ganoderma lucidum on Quercus palustris  
Scolecconectria cucurbitula on Cedrus deodara (first report)

CORRELATIONS OF TURF QUALITY IN NATURAL SHADE WITH ROOT AND RHIZOME GROWTH OF KENTUCKY BLUEGRASS STRAINS. L. H. Taylor and R. E. Schmidt\*. Dept. of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Sod plugs of 15 cm diameter taken from 52 strains of Kentucky bluegrass in a NE-57 Regional Trial were established under natural deciduous shade at Blacksburg in November, 1975. These mini-plots were evaluated for turf quality in shade in 1976 and 1977 and comparisons made with turf performance in full sun. By the second year of growth in the shade there was little correlation of turf quality ratings of these strains in sun and shade.

Sod strips were removed from the NE-57 Regional trial in 1974 and sod strength, regrowth from rhizomes and rooting of sod pieces in sun and shade were measured. In the shade study, spread from the original sod plugs was measured in the fall of 1977 and number of live shoot buds, initiation of new growth and dry weight of plant material were recorded at the termination of the study in April, 1978. Through correlation analysis, these characteristics will be compared with each other and with evaluations of turf quality in shade. Apparent relationships of underground growth to satisfactory Kentucky bluegrass performance under natural shade will be discussed.

RESPONSE OF THREE TOBACCO TYPES TO EXTREME MACRO-NUTRIENT VARIATIONS. T. R. Terrill, V.P.I. & S.U. Southern Piedmont Ctr., Blackstone, Va. 23824

The influence of nitrogen (N), phosphorus (P), and potassium (K) on the yield and quality of most crops has been determined in separate experiments conducted throughout the world. The simultaneous evaluation of 3 tobacco types (flue-cured, sun-cured, and Virginia Dark-fired) under the same environmental and nutritional conditions has provided a comparison of nutritional efficiencies and nutritional thresholds for the tobacco types.

A 4-year study (1974-77) was conducted at the Southern Piedmont Center, Blackstone, Va., on soils which were very low in P & K content. Levels of fertilization were 50, 100, and 150 lb/A for nitrogen; 0, 100, and 200 lb/A for P<sub>2</sub>O<sub>5</sub> and; 0, 150, 300 lb/A for K<sub>2</sub>O.

Flue-cured tobacco demonstrated the highest yield potential and sun-cured tobacco the lowest. Topping heights and the number of plants per acre were lower for sun and dark tobaccos than for flue-cured tobacco (each type managed in recommended fashion), but the utilization of nutrients differed more than management changes and the flue-cured type was most efficient. Both P and K were limiting nutrients for each tobacco type, but sun-cured tobacco demonstrated less response to higher P and K levels than flue-cured tobacco.



INFLUENCE OF EARLY PLANT DEVELOPMENT ON YIELD AND QUALITY OF TOBACCO. T. R. Terrill, M. J. Rogers\*, and J. J. Reilly\*. V.P.I. & S.U., Southern Piedmont Ctr., Blackstone, Va. 23824

Early plant growth was inversely related to leaf yield and quality of flue-cured tobacco (*Nicotiana tabacum*). Measures of growth were obtained on a weekly basis, beginning 4 weeks after transplanting. Characters observed were plant height, leaf, number, and the dry weights of leaves, stems, and roots. Six flue-cured cultivars were evaluated in conjunction with 3 planting dates and 2 nitrogen levels. Tests were conducted at the Southern Piedmont Ctr. in 1976 and 1977.

Date of planting and cultivar influenced early growth and final leaf yields. Early-planted tobacco grew more slowly during the early production period, but surpassed the late-planted tobacco for most measures of growth by the 4th sampling period (7 weeks after transplanting) and developed the greatest cured leaf yields. Similarly, the high yielding cultivars (McNair 944 and Coker 347) developed more slowly than Coker 319 and Coker 187-Hicks, which flowered and matured early.

Rapid, early plant growth, whether the result of seasonal (planting date) or genetic differences, was not beneficial for the maximum production of flue-cured tobacco.

GROWTH REGULATOR ALTERATION OF LIPID METABOLISM; POTENTIAL FOR CHANGING PLANT RESISTANCE. L. K. Thompson and M. G. Hale. Dept. of Plant Path. and Physiol., VPI & State University, Blacksburg, Va. 24061.

Application of growth regulators which change the chemical constituents of plants may be another way to make plants resistant to stress. Among those constituents which are altered are free sterols, free fatty acids and hydrocarbons in the lipids. Peanut plants were cultured axenically in nutrient solutions under controlled conditions in growth rooms. After 50 to 60 days Ciberrellic acid ( $GA_3$ ), 200 mg/l, and 2,4-Dichlorophenoxyacetic acid (2,4-D), 100 mg/l, were applied foliarly for 3 successive days beginning 5 days before harvest. 6-Furfuryl amino purine (kinetin) at  $10^{-6}$  and  $10^{-4}$  M was applied to the roots in the nutrient solution 5 days before harvest. At harvest the plants were divided into leaves, stems, roots and pegs which were analyzed individually by thin layer and gas-liquid chromatography. Exudates collected in the nutrient solutions were also analyzed. Free sterols, free fatty acids and free hydrocarbons were altered from 0 to several hundred percent of control. Aside from the physiological significance of these changes, the constituent content can have a large effect on resistance of the plant. Free sterols and fatty acids have been shown to be growth regulators for fungi and other microorganisms as well as higher plants. Therefore, changes in constituents which alter resistance need to be tested under stress conditions and long-term effects measured.

SCROTAL CIRCUMFERENCE AND TESTICULAR CONSISTENCY OF YEARLING BEEF BULLS ON PERFORMANCE TEST IN VIRGINIA. C. R. Underwood\*, T. N. Meacham\*, K. P. Bovard, T. L. Bibb\*, A. L. Eller, Jr.\*, and M. B. Wise. Dept. of Animal Science, Va. Polytechnic Inst. and State University, Blacksburg, Va. 24061.

This study was conducted to: (a) determine scrotal circumference (SC) and testicular consistency (TC) at the beginning (I) and end (F) of 140-day performance test for yearling beef bulls; (b) correlate these values with performance data; (c) study the relationships between several semen traits, SC and TC. Data presented were restricted to the Angus (A) and Polled Hereford (PH) breeds.

FSC means for the A breed ( $n \geq 20$ ) were 33.0, 34.4, 36.1, 37.0 and 37.9 for 30-day age groups from 331 to 480 days, respectively. FSC means for the PH breed ( $n \geq 20$ ) were 32.3, 33.8, 34.2, 35.5 and 35.9 for 30-day age groups from 331 to 480 days, respectively. FSC shows highest correlations with final weight, .64 and .44, and with age, .47 and .40 for the A and PH breeds, respectively ( $P < .01$ ). The best linear relationship for predicting FSC for bulls completing 140-day performance test was  $\hat{Y} = b_0 + b_1X_1 + b_2X_2 + e_1$ , where  $\hat{Y}$  is the FSC in cm.,  $X_1$  is test ADC by breed in kg,  $X_2$  is ISC in cm., and  $e_1$  is error. Least-squares means analysis for FSC showed significant effects due to breed and location.

SC was correlated with first ejaculate volume, .53 and sperm output, .55 ( $P < .01$ ) and with second ejaculate volume, .57 ( $P < .05$ ) and sperm output, .71 ( $P < .01$ ). TC was not significantly correlated with semen traits.

AN EVALUATION OF ASPERMATOGENESIS IN MALE WHITE MICE. B. B. Thomas\* J. S. Clauss\* H. G. Kattesh\* and J. W. Knight\* Department of Animal Science, VPI&SU, Blacksburg, VA 24061

Previous studies have established that injection of a testicular homogenate with a complete adjuvant results in a cessation of spermatogenesis and degeneration of the germinal epithelium in the seminiferous tubules. The autoimmune response has been shown to be highly species and tissue specific. In this study, adult male white mice were randomly allotted to 6 treatment groups of 5 mice each. Treatments consisted of subcutaneous injections of one of the following: mouse testicular homogenate (MTH), *Bordetella bronchiseptica* vaccine (BB), MTH + BB, MTH + Freund's adjuvant (MTH + FA), estradiol-17- $\beta$  ( $E_2$ ) and control (saline). Treatment effects were evaluated by an examination of testes weight, serum testosterone (T) and androstenedione concentrations and histological examination of the testes. Testes weight and T and A conc. were depressed ( $P < .05$ ) in  $E_2$  treated mice, but no other significant ( $P > .10$ ) treatment effects were noted. No histological evidence of aspermatogenesis was seen in any treatment group, but the number of Leydig cells was drastically reduced in  $E_2$  treated mice.

AIR CONDITIONED HOUSING AS A MEANS OF REDUCING THE DELETERIOUS EFFECTS OF SUMMER HEAT ON BREEDING EFFICIENCY OF SOWS. H. R. Thomas, E. T. Kornegay and J. W. Knight. Dept. of Animal Science, VPI & SU, Suffolk, Va. 23437 and Blacksburg, Va. 24061

A total of 144 crossbred sows were used in three trials (48 sows per trial) during the summer of 1975, 76 and 77 to evaluate air conditioned housing as a means of reducing the deleterious effects of summer heat on breeding efficiency of sows. One-half were assigned to an air conditioned (AC) environment. During 1975, the temperature varied from 72°F in the am to 82°F in the pm. During 1976 and 1977, the temperature was maintained at 70°F. The remainder of the gilts were assigned to a naturally ventilated open sided building (OS) where ambient temperature varied and ranged from 70°F at night to 95°F during the day. Sows were randomly assigned to treatments at weaning or just prior to breeding and remained for 30 days postbreeding. Boars were housed in the air conditioned building. Conception rate, number of stillborns and birth weights were not different between treatments. Sows housed in the AC building farrowed on the average, more pigs per litter; however, this difference was significant ( $P < .05$ ) only in 1977. In 1976 the average litter wt. and the average number of pigs alive at 7, 14, 21 and 28 days of age was significantly ( $P < .01$ ) greater for the AC treatment.

APPLICATION OF WIND ENERGY FOR COOLING APPLE STORAGES. D.H. Vaughan, Dept. of Agricultural Engineering, VPI&SU, Blacksburg, VA. 24061.

A wind-powered apple cold storage facility was designed and constructed on the Horticulture Research Farm at VPI&SU. The facility includes a 10-kilowatt wind generator, nickel-cadmium storage batteries, a cold storage building, a vapor compression refrigeration system, and a thermal storage unit. The wind generator is a horizontal-axis, 3-bladed, high-speed propeller windmill and is mounted on a 90-ft. reinforced radio tower. One thousand bushels of 5 varieties of apples are stored in the building (Feb.-May 77), which is insulated to minimize energy requirements. The refrigeration system has a 3-horsepower d.c. motor-driven compressor with freon 12 refrigerant. Thermal storage is accomplished with a total of 90 7-ft. long 6-inch diameter pipes filled with water and a small amount of ethylene glycol. When power from the wind is sufficient, heat is removed from the solution which then acts as a thermal storage for periods when wind energy is unavailable. The freezing point of the water/ethylene glycol mixture is adjusted to provide the latent heat of fusion at the temperature desired in the storage room. (Acknowledgments: Cooperators include J. A. Schetz and T. A. Weisshaar, Aerospace and Ocean Engr.; W. F. O'Brien and H. L. Moses, Mechanical Engr.; and G. E. Mattus, Horticulture. Research supported by USDA/ARS and DOE as part of the national "Farm and Rural Applications of Wind Energy" program.)

AN ENERGY POLICY FOR THE FOOD SYSTEM OF THE UNITED STATES. D. H. Vaughan, Dept. of Agricultural Engineering, VPI&SU, Blacksburg, Va. 24061

Food and energy are essential for human existence. Because of dwindling energy supplies and uncertain food reserves, scientists, educators, designers, industrialists and administrators from throughout the U.S. were brought together to discuss, debate, and formulate an energy policy for the U.S. food system as an integral part of the overall national energy policy. This conference, titled "Energy's Role in Food Production" and sponsored by the Engineering Foundation and the American Society of Agricultural Engineers, was held at the Asilomar Conference Grounds, Pacific Grove, California on February 6-11, 1977. A document titled, "Energy Policy for the U.S. Food System - A Subpart of a National Energy Policy" was prepared and copies sent to the Secretary of the U.S. Department of Energy, selected U.S. senators and congressmen, university administrators for food and agricultural research, and state governments and energy offices. The document includes 5 specific policy statements related to conservation, substitution for scarce fuels, use of renewable resources produced on the farm, and priority needs for critical uses. (Copies of this document are available from the author.)

ENERGY-COST BUDGETS FOR CORN AND SOYBEAN CROPPING SYSTEMS. O. H. Vaughan, E. S. Smith\*, and H. A. Hughes\*, Dept. of Agricultural Engineering, VPI & SU, Blacksburg, Va. 24061

Energy requirements for three tillage practices (conventional, reduced tillage, and no-tillage) commonly used for corn and soybean production in Virginia were computed and compared. Energy inputs included 1) fuel for field machinery operations including harvesting; 2) fertilizer, insecticide, herbicide, and seed production; and 3) the manufacture, distribution, and repair of field machinery. Compared to conventional tillage corn, the reduced tillage and no-tillage systems resulted in an energy saving equivalent to 0.7 and 3.0 gallons of diesel fuel per acre, respectively. For soybeans, the corresponding figures were 0.4 and 5.1 gal/ac, respectively.

Labor requirements for the various tillage schemes were also compared. For corn production, 2.24, 1.37, and 0.97 hours/acre were required for conventional, reduced, and no-tillage, respectively. Since the spring labor requirement was even less, a farmer could increase his corn acreage by more than 50% by using no-tillage practices. For soybeans, 2.06 and 1.19 hr/ac are required for conventional and reduced tillage practices, respectively, as compared to only 0.47 hr/ac with no-tillage.

Although no-tillage corn and soybean production offer energy and labor savings for Virginia farmers, they are not recommended without a dead vegetative mulch cover or where weed and grass infestations cannot be controlled with selective herbicides.

ESTIMATING SOUTHERN PINE BEETLE TIMBER DAMAGE, F. C. Walters\* and W. A. Leuschner, Dept. of Forestry and Forest Products, VPI & SU, Blacksburg, VA 24061.

Adult Southern Pine Beetles (*Dendroctonus frontalis* Zimm.) (SPB) bore galleries within the cambium and girdle the tree causing its death. Timber damages occur from tree mortality and changes in the subsequent stands. Estimating SPB timber damages requires two steps. First, volume losses from timber mortality must be estimated using either surveillance, ground checking, or aerial surveys. Second, the dollar value of timber mortality and changes in the subsequent stands must be estimated. A present net worth evaluation model is appropriate because it considers the time value of money and can reflect changes in the subsequent stands. Timber damages are measured by the present value of a timber stand with SPB attack minus the present value of the same stand without SPB attack. (Funded by CSRS project 804-15-1).

AN EXAMINATION OF THE EFFECTS OF UNILATERAL AND BILATERAL CASTRATION IN MALE WHITE MICE. W. E. Wyatt\*, B. O. Oganbameru\*, H. G. Kattesh\*, and J. W. Knight\*, Department of Animal Science, VPI&SU, Blacksburg, VA 24061

An experiment was conducted to study the effects of bilateral and unilateral castration on body weight, testes weight, and serum and testicular testosterone concentration. Fifty-two adult male white mice were randomly allotted to one of three treatments as follows: 21 bilateral castrates (BC), 18 unilateral castrates (UC), and 14 sham castrates (SC). One-fourth of each treatment group was sacrificed at 1, 2, 3, and 4 weeks post-surgery. Analyses of variance were conducted for body weight (BW), right testis weight (RTW), left testis weight (LTW), left testis weight per body weight (LTW/BW), left testicular testosterone concentration (LTT), and serum testosterone concentration (ST). The least squares model proposed for BW and LTW was  $\hat{Y} = B_0 + b_1X_i + b_2X_j + b_{12}X_{ij}$  ( $X_i$  = weeks,  $X_j$  = treatment, and  $X_{ij}$  = week by treatment interactions). Least square means for BW were 37.74, 40.71, and 40.74 g for BC, UC, and SC, respectively. Analysis of variance for BW indicated significant treatment effects ( $P < .05$ ). Least squares means for LTW were .0874 mg for UC and .1026 mg for SC. LTT and ST concentrations ( $r = .80$ ) indicated a non-significant increase in UC for week 4.

GROWTH RETARDATION OF TURFGRASSES. G. R. Young\*, S. W. Bingham, K. A. Langeland\*. Dept. Plant Path. and Physiol. V.P.I. & S.U., Blacksburg, VA 24061

The following growth regulators were applied on 'Kentucky 31' fescue (*Festuca arundinacea* Schreb.) and 'Merion' Kentucky bluegrass (*Poa pratensis* L.): CME 10951 (chemistry not disclosed), melfluidide (N-(2,4-dimethyl-5-[(trifluoromethyl) sulfonyl]amino)phenyl) acetamide) and triclopyr (3,5,6-trichloro-2-pyridyloxyacetic acid). Melfluidide was used in combination with Maintain<sup>R</sup>, 2,4-D, dicamba, dicamba + 2,4-D, and maleic hydrazide. Effectiveness of the growth regulation was measured via visual discoloration, density, plant height, clipping weights and weed control. The inflorescence emergences were counted per 900cm<sup>2</sup> on the 'Ky 31' fescue. CME 10951 and melfluidide were examined with three mowing times in relation to treatment. Distinct discoloration on both grasses was observed 5 weeks after treatment, after which steady improvement resulted to 9 weeks. Bluegrass density was affected but no observable effects were exhibited on the fescue. All treatments displayed some degree of height reduction. Melfluidide inhibited inflorescence emergence by about 85% at the 9 week termination of study. The clipping weights showed the greatest growth reduction for the first month; however, the second month, growth reduction recovered to near control levels. Melfluidide and triclopyr showed no effective weed control; however, the melfluidide herbicide combinations and CME 10951 were effective controlling problem weeds.



# Section of Astronomy, Mathematics, and Physics

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

LANGLEY EXPERIENCE IN COMMERCIAL AND RESIDENTIAL ENERGY RELATED FIELDS. Ira H. A. Abbott\*, NASA/Langley Research Center, Hampton, Virginia.

The Langley experience in energy related fields as demonstrated by three projects is discussed.

Project RECOUP is a project to build a refuse burning steam plant in cooperation with Langley Air Force Base and City of Hampton. After completion the steam plant will be operated by the City of Hampton to burn their refuse. The steam produced will be purchased by NASA/Langley. The city and Langley will be able to reduce the use of landfills and steam will be produced without the use of fossil fuels.

The solar Building Test Facility is a large solar heated and cooled office building. The solar field is also operated as a test bed to evaluate solar collectors while in use.

The NASA Tech House is a single family residence designed and built at Langley to demonstrate new NASA technology available to the homebuilding industry. A one year live-in test is being conducted at the house this year. The house and early results of the test will be discussed.

AN ANALYTIC VERSION OF THE ITERATED BLOW PROBLEM. L. Neel Beard\*, Dept. of Physics, Hampden-Sydney College, Hampden-Sydney, Va. 23943.

An algorithm has been developed for the plotting of a segmented elliptical path of a satellite orbiting a 'massless' planet. The exercise is intended for use by students in an introductory astronomy or mechanics course, and employs a programmable calculator or minicomputer in an interactive mode.

The program is initiated by the choice of polar coordinates for two points on the orbit, the first being at apogee. The eccentricity of the projected elliptical path defined by the points is then calculated by the program. If the eccentricity falls between stipulated bounds, the student is instructed to proceed. Two sets of coordinates are computed by the program: those of a point on the extrapolated straight-line path; also, those of the next point on the elliptical path. The student plays the role of navigator, and specifies components of a vector which, if applied to his inertial path, would place his next point on the elliptical path. The procedure is iterated around a half-orbit.

The experiment was suggested by a similar version appearing in Project Physics, which was graphical.

AN UPPER BOUND FOR THE CARDINALITY OF LINDELÖF SPACES, Arthur Charlesworth, Dept. of Mathematics, University of Richmond, Richmond, Va. 23173

In 1969 the Russian mathematician A. V. Arhangel'skii solved a fifty year old problem by proving that a Lindelöf space in which every point has a countable local base can have no more points than the unit interval  $[0,1]$ ; that is, its cardinality cannot exceed the continuum  $c$ . Arhangel'skii then asked whether it is possible to weaken the condition on the Lindelöf space to requiring only that every point be the intersection of countably many open sets. In order for Arhangel'skii's question to be answered affirmatively, it is clearly necessary that every such space must have a separating<sup>1</sup> open cover consisting of  $\leq c$  open sets. We have been able to prove that this condition is also a sufficient one; in fact, we have the following stronger result. Let  $X$  be a Lindelöf space in which every point is the intersection of countably many open sets. If  $X$  has a separating open cover such that each point is in  $\leq c$  members of the cover, then the cardinality of  $X$  is  $\leq c$ . The proof of the result permits an extension to higher cardinal numbers.

<sup>1</sup>A cover  $\mathcal{U}$  for a space is separating if for each pair of distinct points  $x$  and  $y$  of the space, some member of the cover contains  $x$  but does not contain  $y$ .

SOLAR ACTIVITY AND EARTH'S CLIMATE. Kuldip P. Chopra, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

There is a general agreement among meteorologists and climatologists that for reasons unknown to them, quiet sun produces severe winters whereas the appearance of colder sunspots produces warmer winters. The severe winters appear to correlate well with the solar cycle. There is also some evidence of enhanced thunderstorm activity and anomalous rainfall patterns which follow solar flare and auroral activities. Physical mechanisms based on the alterations in the patterns of solar particulate and electromagnetic radiation spectra and their interaction with Earth's atmospheric, hydrospheric and magnetic environment. In particular, the anomalous patterns of rainfall can be explained in terms of the precipitation of X-ray and UV produced electrons in the auroral zone and planetary circulations in the troposphere.

ONE DIMENSIONAL INHOMOGENEOUS VLASOV EQUILIBRIA. F. R. Crownfield, Jr., College of William and Mary, Physics Dept., Williamsburg, Virginia 23185

Bernstein, Greene and Kruskal showed how, given the electrostatic potential as a function of position, the entire distribution function for ions, and the distribution function for untrapped electrons in a one dimensional, two species Vlasov plasma, one could determine the distribution function for the trapped electrons as the solution of an Abel integral equation. This result is generalized by replacing the statements about the distribution functions with the specification of the velocity space distribution functions of both species at a single position in the plasma. Limiting cases are shown to correspond to the earlier treatment, and the applicability of the theory to experiment is discussed. (Supported in part by NASA.)

BEHAVIOR MANAGEMENT AND ENERGY CONSERVATION. E. Scott Geller, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

The role of applied behavior analysis in the implementation of a community education model for energy conservation (CEMEC) was discussed. More specifically, CEMEC workshops that we administered in urban and rural communities included the following concepts: 1) contingency management to promote simple energy-conserving changes in one's lifestyle, 2) the use of contingency contracting to promote specific energy-conservation activities following the workshops, 3) the collection of baseline and treatment data so as to demonstrate the relative efficacy of particular energy-conservation interventions. The results of comprehensive attitudinal and behavioral observation indicated significant discrepancies between individuals' energy-conservation attitudes and behaviors. That is, the attitude assessments administered before and after the 3-hr. CEMEC workshops showed prominent, beneficial effects of the workshop on attitudes and opinions related to energy conservation. However, actual visitations to the homes of 40 workshop participants and 40 residents who had not attended a CEMEC workshop indicated minimal behavioral effects of the workshops. For example, the groups were equivalent with regard to thermostat settings, and condition of water heaters (temperature and insulation). The potential role of prompting, feedback, and reinforcement were discussed as necessary for promoting energy-conservation action.

AN ARGON CALIBRATION STUDY OF A RESONANCE TUBE AT LOW F/P RATIOS.† W. A. Griffin, Old Dominion Univ., Norfolk, Va. 23508

This study concerns the calibration of a resonance tube designed to investigate sound absorption in  $N_2-H_2O$  gas mixtures at ambient temperature and frequency/pressure (F/P) ratios in the range 0.1-1000 Hz/atm. The tube has an operating pressure range of 1-100 atm and measures 60-ft in length by 0.5 ft inside diameter. The free-decay technique is employed in the measurements.

The significant sound absorption mechanisms arising in an ideal resonance tube containing the diatomic gas nitrogen, under acoustical excitation at low F/P ratios and ambient temperature, are those due to vibrational relaxation and wall losses. If the monatomic gas argon is used under the same conditions, only wall losses occur. This knowledge is essential to permit tube calibration at the lowest loss level and providing a measure of the tube acoustical quality. High acoustical quality (wall losses close to theoretical) is mandatory to the design goal of locating the low-amplitude nitrogen vibrational relaxation peak on the F/P axis as a function of humidity. The peak height is estimated to have a value of absorption coefficient  $\mu \sim 7 \times 10^{-4}$  nepers/wavelength.

Experimental results indicate that the observed losses are in agreement with the theoretical wall losses for most of the frequencies excited.

† Work supported by NASA.

SOLAR ENERGY INSTALLATIONS IN VIRGINIA. Richard P. Hankins, Jr.,\* Chief Energy Engineer, Torrence, Dreelin, Farthing and Buford, Inc., P. O. Box 11084, Richmond, VA 23230, and Chairman, Va. Solar Energy Association, P. O. Box 12442, Richmond, VA 23241

If you pick a good application for solar energy, design a good simple system and install the equipment properly, a solar energy system can be a good investment for both public and private enterprise.

A number of solar energy systems have been installed throughout the Commonwealth of Virginia. The applications include heating and cooling buildings, heating domestic and process hot water and heating swimming pools. Some of the collectors are factory made, some are built-in-place and some are homemade. The talk will be a slide show of solar energy projects in Virginia.

OBJECTIVES FOR THE NEW VIRGINIA CENTER FOR COAL AND ENERGY RESEARCH. W. R. Hibbard, Jr., University Distinguished Professor of Engineering and Director of the Virginia Center for Coal and Energy Research, V.P.I&S.U., Blacksburg, Va., 24061.

The Virginia Center for Coal and Energy Research was created by Act of the General Assembly of Virginia on March 30, 1977. The Board of Visitors of Virginia Polytechnic Institute and State University authorized the establishment of the Center on July 27, 1977 and appointed the Director. The Center is an interdisciplinary study, research, information and resource facility for the Commonwealth of Virginia utilizing the full capabilities of faculty, staff, libraries and laboratories for the benefit of Virginians and the expansion of knowledge pertaining to coal and energy research and development.

Statutory duties and functions of the Center include:

1. To conduct research in the fields of coal, coal utilization, migrating natural gases such as methane and propane, and other energy related work.
2. To develop and provide programs of continuing education and in-service training for persons who work in the field of coal or other energy research, development or production.
3. To foster the utilization of research information, discoveries and data.

SOME DEVELOPMENTS IN OPTICAL MODULATION SPECTROSCOPY, R. Wayne Major, Dept. of Physics, Univ. of Richmond, Va. 23173

Recent advances in high-frequency (50 kHz) photoelastic modulation of polarization have resulted in a useful technique for probing magneto-optical properties of defect centers in solids, as well as in non-solid chemical compounds. Magnetically-induced circular dichroism (MCD) can be readily measured and leads to such information as the orbital magnetic moment and spin-orbit splitting of excited states of  $F^+$  centers in alkaline-earth oxides. More prosaic applications include simple, accurate measurement of intrinsic optical activity, Faraday rotation, and birefringence.

Another form of modulation under study by the author is that of one light beam by another. A weak two-beam interaction is effected by low-power laser excitation of electron-hole pairs in II-VI semiconductor crystals. This alters the absorption of a primary light beam in the sample. The effect is extrinsic, has a polarity depending on primary photon energy, and displays kinetics sharing some characteristics of photocurrent behavior. In ZnSe, Cu is possibly a major source of the levels at which selective trapping alters the carrier concentration. Photon-capture cross-sections at 510 nm are in the range  $0.3 \times 10^{-16} - 0.9 \times 10^{-16} \text{ cm}^2$ , corresponding to non-equilibrium carrier concentrations  $\Delta n \approx 10^{13} \text{ cm}^{-3}$ .



COMPARISON OF HYDROGEN AND DEUTERIUM PLASMAS IN A MULTIDIPOLE SYSTEM. L. B. Marshall, Dept. of Physics, James Madison Univ., Harrisonburg, Va. 22801

The properties of H<sub>2</sub> and D<sub>2</sub> plasmas such as electron temperature, density, and density profiles are investigated in a multidipole system. The hydrogen ion beam current extracted from a multidipole source is found to be higher than a deuterium ion beam. However, no significant difference is observed in the composition of the ion species.

STATE WIDE ENERGY EXTENSION ACTIVITIES. William H. Mashburn, Mechanical Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

To meet the ever changing needs of the people of the Commonwealth of Virginia, the Extension Division of Virginia's land grant university periodically reviews and revises its priorities. The most complex problem that it has had to cope with to date is that of energy. This affects all program areas and involves a multitude of disciplines. Programs must deal with apathy, attitudes and tradition as well as complex technical subject matter. Target audience identification, barriers to technology transfer, and techniques for transferring energy technology to the various audiences are discussed in this presentation.

USE OF TECHNICAL PROFESSIONALS FOR ACHIEVING PUBLIC ENERGY AWARENESS, R. Naismith\*, Atlantic Research Corporation, Alexandria, Va., 22314

Technical professionals have a unique role to play in the search for solutions to our energy problems. Aside from efforts in the laboratory, they can provide a vital communication link. The energy issues are so critical to our national survival that social and political factors will often have greater weight in the decision process than technical considerations. The technical professional seldom deals with these factors, but he must if he wishes to affect the outcome of our energy policy making. One way of doing this is to provide an understandable translation of the technical issues to the general public. Sound policies most often come with the support of informed, motivated citizens.

In Northern Va., the Joint Engineering Energy Committee (JEEC) provides the framework in which professionals can work. JEEC is a public service organization comprised of volunteers interested in improving the efficiency of energy use. Members include professionals from several technical societies and other interested citizens. Their major contribution is technical support to the community through existing institutions. One of the activities is public service workshops. During 1977, JEEC developed an Energy Saving Workshop for Homeowners which was adopted for use by the Va. Energy Office as its outreach program last Fall. The 1978 program is entitled "Energy and the Environment." Other activities of JEEC include participation on the Energy Task Force of Fairfax County.

Franck-Condon Factors for the  $C^3\pi_u \rightarrow B^3\pi_g$  Second Positive System of  $^7N_2$

M. L. Ramesh Rao\* and Dr. G.E. Copeland, Department of Physics and Geophysical Sciences, Norfolk, VA 23508

Franck-Condon Factors (vibrational transition probabilities) have been evaluated by a numerical integration technique for the  $C^3\pi_u \rightarrow B^3\pi_g$  second positive system of the  $^7N_2$  molecule using a Morse potential function for vibrational levels  $v'' = v' = 0$  to 10. Results compare favorably (order of 2%) with previous calculation by Zare, et.al., who used Rydberg-Klein-Rees potential and Jarman and Nicholls<sup>2</sup> who used an effective Morse potential.

1. R.N. Zare, E.O. Larsson and R.A. Berg, J. Molecular Spectroscopy 15, 117 (195)
2. W.R. Jarman and R.W. Nicholls, Cand. Journal of Physics, Vol. 32, 201 (1953)

\*Candidate for a Master of Science in Physics

FITS FOR PRODUCTION CURVES OF MINERALS AND ENERGY RESOURCES. L. D. Roper, Dept. of Physics, VPI&SU, Blacksburg, VA 24061

By fitting U.S. minerals production data to the Verhulst function, one finds that the highly depleted minerals group into three categories characterized by the ratio (n) of the fall time constant to the rise time constant. Mercury, platinum group, and uranium have  $n \approx 15$ ; silver, zinc, lead, cadmium, and helium have  $n \approx 5$ ; and gold, tungsten ore, and cobalt have  $n \approx 1$ . There are other metals (chromium, manganese, niobium-tantalum, and tin) for which there have been only sporadic production in the U.S. Oil and natural gas are just now at the production peak, so the value of n for them cannot be obtained. However, one would expect that their production will be in either the  $n \approx 5$  or  $n \approx 15$  category. Oil and gas production predictions for these two cases will be given.

USE OF A CORRELATION INTERFEROMETER TO MEASURE ATMOSPHERIC CARBON MONOXIDE. L. L. Vian\*, Dept. of Physics Old Dominion Univ., Norfolk, Va. 23508

Due to the possible health hazards of atmospheric carbon monoxide, a correlation interferometer and remote sensing instrument to measure the atmospheric carbon monoxide with sufficient accuracy to locate global carbon monoxide sources and sinks. The principles of interferometry, advantages of interferometers, and the applicable radiative transfer theory are discussed as they relate to the technique.

DIVISION OF ENERGY, STATE OFFICE OF EMERGENCY SERVICES PROGRAMS IN ENERGY CONSERVATION. J. Temple Bayliss,\* J. Boyd Spencer\*. Division of Energy, 823 East Main Street, Richmond, Virginia 23219

In cooperation with VPI and SU, the Division will offer a free computerized analysis of home energy use and of measures to reduce energy consumption to residents of Virginia by late summer. The analysis will be similar in concept to project conserve, but will indicate expected annual energy use for heating and cooling and savings to be obtained. This service will be offered together with an authoritative manual on home energy conservation, a toll free telephone consulting service, and, tentatively, a free shower flow restrictor. All services will be extensively publicized.

This spring, the Division will distribute both a comprehensive energy audit workbook and a list of professional engineers qualified to do audits to managers of office buildings in the Richmond Area.

A program of industrial conservation workshops, hosted by industries which have already developed energy management plans, is scheduled for the fall.

Planning is also proceeding for programs under the National Energy Act.

COMPUTER ANALYSIS OF HOME ENERGY USE. Samuel P. Bowen, Physics Department, V.P.I. & S.U., J. Temple Bayliss, Virginia Energy Office, Richmond.

A computer analysis of home energy use originally created by Dr. Richard Spray of V.P.I. Extension Division was adapted as an analysis tool for citizen home energy analysis. The program utilizes a simplified algorithm based on an effective degree day method to analyze major areas of heat loss (or gain) in a home and to present a ranked list of retrofit alternatives for the home. The ranking includes approximate costs, savings, and investment evaluations. The program is designed to give the simplest approximate heat loss analysis consistent with the minimal information that citizens are willing to supply. The program has been calibrated against several houses and has been field tested in several regions of Virginia. Descriptions of the questionnaire, output, and program testing will be given.

DEMONSTRATIONS - THE SIMPLER THE BETTER. D.R. Carpenter, Jr. and R. B. Minnix. Dept. of Physics, VMI, Lexington, Va. 24450.

Physics demonstrations seem to be an effective teaching tool of interest to elementary, high school or college students and adults alike. Simple apparatus is easier to construct and set up. It has the psychological advantage of making the principles at least appear to be simple.

Demonstrations shown included the pinhole as a magnifier; a paper clip to detect the direction of a magnetic field; showing inertia with a pie pan shot from beneath a raw egg; the rigidity of a spinning chain; and a seat of nails.

Also shown were the response time of the ear with two funnels and a rubber tube; an acoustic cannon; standing waves in a piece of marine waste water hose; traveling and standing waves in a spiral shop air hose filled with water; and uses of L'eggs panty hose containers floating in a stream of air to show Bernoulli's principle, changing axes of rotation when spun and internal friction of raw vs hardboiled eggs.

COMMUNITY EDUCATION MODEL FOR ENERGY CONSERVATION. Robert N. S. Chiang and Robert Schubert, Architecture; Lubna Ijaz and Samuel P. Bowen, Physics; E. Scott Geller, Psychology; J. Rodney Chambers, Vocational Education; Marilyn Grantham, Agricultural Economics; V.P.I. & S.U.

CEMEC is an educational model developed specially for community energy conservation actions. The project's primary objectives are (a) to make the community participants aware of the scope and seriousness of our current energy situation; (b) to enable and motivate participants to take energy conservation actions with information provided by the project resources; (c) to help participants make appropriate decisions; and (d) to develop, implement, evaluate and disseminate an energy-conservation educational model that reflects regional, community, and family concerns. The model is specially assembled for three audience categories: (I) government and public facilities administrators; (II) business and industrial leaders and (III) community leaders and consumers.

The prepared resources have been field tested through workshops in two areas: south-west Richmond and the fourth planning district in western Virginia. CEMEC resources have been developed in the format of a consumer education manual including the following types of materials: (a) Question and answer pamphlets; (b) "How To" brochures; (c) field use check lists; and (d) technical notes to reinforce the above three types with detailed information and data as needed.

The CEMEC project is a study by title 1A of the HEA of 1965 with the assistance and support of VPI Extension Service.

INFRARED VIBRATIONAL-ROTATION SPECTRA OF THE C<sub>10</sub> RADICAL USING TUNABLE DIODE LASER SPECTROSCOPY. G. E. Copeland<sup>1</sup>, Dept. of Physics, Old Dominion University, Norfolk, Va. 23508; R. S. Rogowski, C. H. Bair, W. R. Wade, and J. M. Hoell, NASA, Langley Research Center, Hampton, Va.

C<sub>10</sub> is a reactive species which participates in the catalytic destruction of stratospheric ozone. The purpose of this study is to provide infrared data useful for atmospheric remote sensing of this free radical. The C<sub>10</sub> infrared absorption lines were measured with a diode spectrometer system<sup>2</sup>. About 50 vib-rot lines were measured and assigned to the <sup>35</sup>ClO and <sup>35</sup>ClO species in the  $2\pi_{3/2}$  states and to <sup>35</sup>ClO in the  $2\pi_{1/2}$  state. C<sub>10</sub> was generated in a flow system where Cl<sub>2</sub> + He is mixed with O<sub>3</sub>. The C<sub>10</sub> concentration was measured by uv absorption and the infrared line positions were referenced to previously measured NH<sub>3</sub> lines. Band center position,  $\nu_0$ , and rotational constants were determined for those two states in both isotopic species. A doubling splitting was observed to be  $\sim 0.02\text{cm}^{-1}$ . Near NH<sub>3</sub> reference lines the C<sub>10</sub> line positions are measured to  $\pm 0.004\text{cm}^{-1}$ .

<sup>1</sup>NASA/ASEE Summer Faculty Fellow, 1977, Langley Research Center

<sup>2</sup>P. Brockman, C. H. Bair, F. Allario, *Applied Optics* 17, 91 (1978)

ATTEMPTS TO MEASURE THE COMA OF THE EYE. I. I. Epstein and R. M. Malatin\*, Dept. of Biophysics, Med. Coll. of Va., Va. Commonwealth Univ., Richmond, Va. 23298

In retinoscopy (an adaptation of the Foucault knife-edge test to the prescribing of eyeglasses), coma manifests itself through shadows closing in from both sides. In an earlier communication (Va. Journal of Science 25, 55 (1974)), an attempt was described to neutralize the coma by placing a decentered optical system in front of the eye. This failed because the minute irregularities of the cornea make themselves felt. Calculations and a preliminary experiment indicate that the coma of the eye can be neutralized by a contact lens of sufficiently strong negative power. Once the power of the contact lens which achieves neutralization is known, the coma of the eye can be calculated. However, it is also necessary to know the curvature and asphericity of the cornea and the distance from the cornea to the pupil (that is the depth of the anterior chamber). These can be measured respectively with a Wesley-Jessen photokeratoscope and by echogram (A-scan).



DESIGN CONSIDERATIONS FOR A LOW COST RADIO TELESCOPE. R. J. Fear\*, and W. H. Ingham. Dept. of Physics, James Madison Univ., Harrisonburg, Va. 22801

The factors which influence the design of a low-cost radio telescope are discussed. Restrictions and decisions regarding the observing frequencies, design of antennas, receiver characteristics, and the methods of recording received power are covered.

A DIGITAL INTERFACE BETWEEN A LANGMUIR PROBE AND A MINI-COMPUTER. Dwight G. Fitzsimons\* and Gerald R. Taylor, Jr. Dept. of Physics, James Madison University, Harrisonburg, Va. 22801.

Factors in the design of an analog-to-digital interface to automatically feed current and voltage measurements from a Langmuir probe into a minicomputer are discussed. Plasma parameters from the probe characteristic are evaluated by the minicomputer.

A STUDY OF THE CHEMILUMINESCENT REACTION BETWEEN OZONE AND ETHYLENE. M. Greer\* and G. E. Copeland. Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

Ambient level (ppb range) air pollutants can be monitored by their chemiluminescent reactions with other species. (1, 2) This work concentrated on a study of the intensity characteristics of an ethylene rich reaction with known amounts of ozone taking place in a specially designed reaction chamber. (3) The intensity of the resulting continuum at 440 nm was measured directly by an EMI-9750B PMT as a function of  $C_2H_4$  and  $O_3$  flow rates. It was found to be linear ( $r > 0.995$ ) with respect to  $O_3$  concentration over the range of 20 to 400 ppbv. Total flow rate (sample +  $C_2H_4$ ) was varied from 615 to 1000 sccm. Maximum sensitivity occurred when flow rate for the sample was 910 sccm and for  $C_2H_4$  90 sccm.

#### References:

- 1) J. A. Hodgeson, Science 182, 248 (1973)
- 2) Radford Byerly, IEEE Trans. in Nuclear Science 22, 857 (1975)
- 3) A. B. Bandy, R. G. Reed, H. Finley, Design, Construction, and Calibration of an Ozone-Ethylene Chemiluminescent Instrument, Old Dominion University (Unpublished)

DRIFTING KINETIC THEORY OF THE EFFECT OF ANGLE OF ATTACK ON THE NON-EQUILIBRIUM DENSITY DISTRIBUTION IN A MOLECULAR SHIELD. J. E. Hueser\* and F. J. Brock\*, Old Dominion Univ., Norfolk, Va. 23508.

In previous discussions of the feasibility of the molecular shield in reducing the density in the vicinity of experiments to be performed in Earth orbit, 0° angle of attack was assumed and solutions were obtained for the density distribution in the molecular shield for a wide range of atmospheric gas parameters. Having shown that the molecular shield can provide an experiment environmental density approx. 7 orders of magnitude below ambient at 200 km, the more general solutions for arbitrary angle of attack were investigated to determine the effects of attitude control instabilities on the molecular density distribution within the shield.

The mathematical formalism to be discussed is the free-molecular, drifting gas analysis of the non-equilibrium density distribution in a hemispherical molecular shield at arbitrary angle of attack. The density at an arbitrary space point  $n(\kappa, \nu, \psi)$  in the hemisphere is considered to consist of two components: primary density, molecules coming directly from the drifting gas; and secondary density, resulting from the multiply scattered flux incident on the inner surface of the shield and emitted to the point  $(\kappa, \nu, \psi)$ . The analytical equations for these two density components will be discussed together with density distribution data obtained by numerical solutions, representing the total atmospheric contribution to the density in the shield for angles of attack 0-12°. (Supported by NASA grant NSG-1271).

SELECTION OF OPERATING WAVELENGTHS FOR REMOTE SENSING OF TROPOSPHERIC GASES USING THE IR DIAL TECHNIQUE. M. Meale Mayo\*, and Frank S. Mills\*. Dept. of Physics, Old Dominion University, Norfolk, VA 23508

Many tropospheric trace and pollutant gases have absorption features in the near infrared suitable for remote sensing measurements. NASA La RC has currently under development, a relatively high power pulsed laser source tunable between 1.5 and 4.0  $\mu m$  which will be used in these studies. In this paper the procedures for selecting proper wavelengths for DIAL operation and for determining the expected measurement sensitivities are described using the  $\nu_1 + \nu_2$  and  $\nu_2 + \nu_3$  bands of  $NH_3$  near 2.3  $\mu m$  as an example. The same procedures have been used to determine operating wavelengths and expected sensitivities for a number of gases using spectroscopic data available in the literature. The results of those studies are also presented in this paper. (This work was supported in part by NSG 1477)

A DENSE PLASMA UV SOURCE. Ja H. Lee\*, Vanderbilt Univ. and D. R. McFarland\*, NASA Langley Res. Ctr., Hampton, VA 23665

The intense ultraviolet emission from the NASA Hypocycloidal-Pinch (HCP) plasma was investigated. The HCP consists of three disk electrodes whose cross sections take the configuration similar to the cross section of a Mather-type plasma focus. A pair of plasma foci ( $T_e \sim 1$  keV,  $n_e \sim 10^{18} \text{ cm}^{-3}$ ) are produced when the maximum compression of the current sheets occurs in the center hole of the apparatus.<sup>1</sup> The plasma foci were produced in deuterium, helium, xenon, and krypton gases to compare their emission characteristics. Time integrated spectra in the range of  $\lambda = 200 \text{ nm}$  to 400 nm and temporal variations of the UV emission were obtained with a UV spectrometer and a photomultiplier system. The spectral intensities ( $> 1 \text{ MW}$ ) of the plasma were determined by photographic comparisons with a standard carbon arc source.

Some modifications to enhance UV emission in the iodine-laser pump band ( $\lambda = 250 - 290 \text{ nm}$ ) and preliminary results will be presented. Also, the advantages of the HCP as a UV source over the conventional xenon lamps will be discussed with respect to power output limit, spectral range, and lifetime.

<sup>1</sup>J. H. Lee, D. R. McFarland, and F. Hohl, Phys. Fluids, 20, 313 (1977).

(Aided by NASA Grant NSG 1235).

CONSTRUCTION OF COMPUTER GENERATED VOLUME HOLOGRAMS (CGVH). J.K. Partin\* and S.K. Case\*, Dept. of Physics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A new type of hologram that combines computer generated holograms (CGH) with volume reflection holograms is described. The reflection hologram acts as an interference filter to select one color of reflected light and the CGH shapes the reflected wavefront to eventually produce the desired image. Therefore a single color holographic image can be produced even when the CGVH is illuminated by ordinary white light. By appropriate adjustment of the angles of incidence of the two holographic construction waves, both the location and the color of the image produced by the CGVH can be arbitrarily selected. The color of the image produced is not necessarily the same as the color of the laser used to construct the hologram. Using the CGVH and multiple exposure techniques, a single color laser (e.g. HeNe) can be used to construct a hologram which will produce multi-colored images.

Potential applications include optical information processing, holographic optical elements, multicolor displays, and lens testing. Calculations are made to determine the range of wavelengths possible for image reconstruction. Experimental results are given and discussed.

EFFECT OF COMBINED SCATTERING MECHANISMS ON THE CONDUCTIVITY AND HALL MOBILITIES OF FILMS. Billy W. Sloope and R.B. Mosley\*. Dept. of Physics and Physical Science, VA. Commonwealth Univ., Richmond, Va. 23284

Electron transport integrals are extended to include multiple charge scattering mechanisms and surface scattering. Results for the conductivity and Hall mobilities are presented for p-type Ge films utilizing acoustical phonon, optical phonon, and strain field dislocation scattering. Temperature and thickness profiles are shown for several dislocation densities. At low temperatures the film and bulk mobilities increase with temperature, pass through a maximum, and decrease with further temperature increase. The film mobilities approach the bulk mobilities not only in the high temperature region but also in the low temperature region, the latter being dependent upon the dislocation density. Thus, the reduction in mobility due to thickness is greatest in the intermediate temperature range.

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ENERGY CONSERVATION PROGRAM FOR HOMEOWNERS. Wayne P. Smith\*, Director, and William E. Lindquist, Energy Section, Fairfax County Department of Extension and Continuing Education, Fairfax, VA 22030

Energy demand continues to grow, despite the rapid escalation of energy costs. The potential for reducing costs through energy conservation is greater than the potential for reducing costs in any other way available to the homeowner. Therefore, an educational "How To" program attempted to persuade the homeowner to look upon energy conservation as an investment opportunity rather than a necessary evil.

This program is an intensive educational effort by a local government to convince its citizenry of the impact each person can have in energy conservation.

STUDIES OF FERROMAGNETIC ALLOYS WITH  $\mu^+$ SR SPECTROSCOPY.

C. E. Stronach, Va. State Col., Petersburg, VA 23803; A. T. Fiory\* & R. P. Minnich\*, Bell Lab., Murray Hill, NJ 07974; W. J. Kossler\*, J. Lindemuth\*, & K. G. Petzinger\*, Col. of Wm. & Mary, Williamsburg, VA 23186; W. F. Lankford, George Mason Univ., Fairfax, VA 22030; K. G. Lynn\*, Brookhaven Nat. Lab., Upton, NY 11973; J. J. Singh, NASA Langley Research Ctr., Hampton, VA 23665.

Polarized  $\mu^+$  from the SREL synchrocyclotron<sup>1</sup> were implanted into Fe(Al) samples containing 0, 1.86, 4.39, and 5.69 at % Al at 301 K with zero external magnetic field. Timing spectra of decay  $e^+$  were taken at 0°, 90°, and 180° with respect to the  $\mu^+$  beam. The measured precession frequencies gave the Knight shift as a function of Al concentration. Subtraction of the bulk magnetization then gave the hyperfine field, which decreased linearly at  $-0.24 \pm 0.06$  %/at % Al. Possible explanations in terms of a rigid band model, enhancement of the spin polarization of the screening electrons, and non-random site sampling by the  $\mu^+$  will be given. (Stronach is aided by NASA grant NSG 1342. Kossler, Lindemuth, Petzinger, and Lankford are aided by NSF grant DMR 77-12602.)

1. SREL is supported by the NSF, NASA, and the Commonwealth of Virginia.

EFFECTS OF AMBIENT HUMIDITY UPON THE X-RAY DIFFRACTING PROPERTIES OF SILICON. Surapong Suwana-Adth\* and William C. Sauder, Dept. of Physics, VMI, Lexington, VA 24450.

Using a monolithic double crystal spectrometer, a device that produces high resolution x-ray spectra [1], we have found that the diffraction width of dislocation-free silicon depends upon the partial pressure of water vapor in the air surrounding the crystal. This has been demonstrated by applying a fitting routine to Cu K $\alpha$  profiles from the spectrometer in order to obtain widths of the line components. We discuss two series of measurements: (1) determining the variation of width vs. relative humidity yields information on the interaction taking place at the crystal surface; and (2) comparing the widths of 111 and 444 Bragg reflections reveals the change of the effect with depth in the crystal.

[1] W. C. Sauder, J. R. Huddle, J.D. Wilson, and R. E. LaVilla, Phys. Letters A (1977, in publication).

PLASMA PROPERTIES IN CONNECTION WITH GAS LASERS. J. W. Wilson, NASA Langley Research Ctr., Hampton, VA 23665; W. L. Harries\*, ODU, Norfolk, VA 23508; R. J. DeYoung\*, Miami Univ., Oxford, OH 45056

The typical gas laser consists of a gas (mixture) filled quartz tube with mirrors at each end to form the laser cavity. Energy is supplied to the gas either through an electrical discharge, microwave heating, a particle beam, nuclear reactions in the tube, flash lamp, etc. Initially, the energy resides in the major gas species of which the plasma is formed. The plasma properties are determined by the gas and the energy source. The population inversion is usually formed in a minority gas species which is coupled to the plasma through impact excitation, excitation transfer through so-called resonant processes, charge transfer (with or without excitation transfer) and Penning ionization. Laser efficiency depends on the strength of the coupling and the inherent quantum efficiency of the system. For a given energy source and major filling gas, the choice of minority gas species for optimum energy output is the principal gas laser design problem. Specific examples from electrical discharge and nuclear pumped lasers will be discussed to illustrate these points.

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## Section of Biology

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

LOCALIZATION, ISOLATION AND CHARACTERIZATION OF ALKALINE PHOSPHATASE, A DEVELOPMENTALLY SIGNIFICANT ENZYME, DURING CELLULAR DIFFERENTIATION OF DICTYOSTELIUM DISCOIDEUM. D. Randall Arment\* and Charles L. Rutherford. Biology Dept., Va. Polytechnic Inst., Blacksburg, Va. 24061

Upon starvation amoeboid cells of D. discoideum undergo a program of differentiation leading to the development of two distinct cell types. Using a microtechnique of enzyme analysis, alkaline phosphatase activity was localized exclusively at the line of demarcation between the two cell types. The enzyme was then partially purified by chromatography on Sepharose-6B, DEAE-Sephadex, phenyl-Sepharose and Concanavalin A-Sepharose. Alkaline phosphatase was solubilized from the membrane with 0.2% Triton X-100 and found to have a molecular weight in excess of 600,000 d. Sepharose-6B gel filtration in the presence of detergent disaggregated the enzyme to a form of about 120,000 d. DEAE chromatography yielded a major and minor peak of enzyme activity. Both peaks were resolved from a micro-DEAE column which utilized microgram quantities of tissue dissected from the line of demarcation in slime mold individuals. A test of substrate specificity showed that only p-nitrophenylphosphate and 5'AMP could be hydrolyzed. (Supported by Nat. Inst. on Aging grant AG00677)

MORPHOLOGICAL AND SYSTEMATIC STUDIES ON THE SECOND INSTARS OF THE GALL-LIKE SCALE INSECTS (HOMOPTERA: COCCOIDEA: KERMESIDAE). R. G. Baer\* and M. Kosztarab. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

In the Nearctic Region, the Kermesidae comprises the genera Kermes Boitard and Olliffiella Cockerell principally found on oaks. Descriptions of Kermes species have been based on old, sclerotized females. These descriptions overlap considerably and no suitable keys have been prepared.

Previous studies by the authors indicate that kermesid first instars can be separated. The genus Kermes can be divided morphologically into three main groups which can be subdivided into ten distinct species or species groups. One Olliffiella species was studied.

Second instars can be separated into species. Their sex can be determined. Eight second instar Kermes females, four second instar Kermes males and one second instar Olliffiella female were studied. Keys were prepared to separate Kermes and Olliffiella second instar females and Kermes second instar females and males in North America.

THE OCCURRENCE OF AQUATIC INSECTS IN MINE RUN, CULPEPER CO., VA. M. L. Bass and R. H. Strickler\* Dept. of Biology, Mary Washington Col. Fredericksburg, Va. 22401

A literature survey found no information listing specific genera of aquatic insects native to the Rappahannock River Basin. This is an introductory report of work being carried out to fill this information gap.

The Rapidan River is the major tributary of the Rappahannock River above the fall line. Mine Run is a small tributary of the Rapidan River. It is approximately 12 km long and has a 5 km branch entering it about 3 km from its origin. Both of these small streams drain an undeveloped area bordering the Rapidan on its north bank. Representatives of eight insect orders were found in these two streams including Diptera, Coleoptera, Plecoptera, Odonata, Megaloptera, Ephemeroptera, Trichoptera, and Hemiptera. The most abundant orders were Coleoptera and Ephemeroptera. The number of different species found increased from 12 in the branch to 28 in Mine Run near its confluence with the Rapidan River.

SURVIVAL OF EUGLENA GRACILIS EXPOSED TO SUBLETHAL TEMPERATURE AND HEXAVALENT CHROMIUM. Barbara L. Berrent, and William H. Yongue. Dept. of Biology and Center for Environmental Studies, Va. Polytechnic Inst., Blacksburg, Va. 24061

Investigations of toxic effects of individual chemicals combined with the heat sensitivity of aquatic organisms has received little attention. This investigation was concerned with the effect of combined sublethal temperature and chromium.

At approximately 20 C or room temperature, 1 mg/l for 3 hours was determined as the chromium (as chromium trioxide) LC50 threshold for Euglena gracilis. Euglena subjected to heat (31.5 C ± 0.5 for 1 hour), cooled to room temperature, and then treated with various concentrations of chromium were equally sensitive to 0.001 mg/l and to 10 mg/l. When concurrently and continuously subjected to 31.5 C ± 0.5 and chromium, each concentration demonstrated a 50% reduction in Euglena survival at the end of 3 hours. Comparing these experimental results to the standards for chromium in drinking water set by the Public Health Service (0.05 ppm), it is important to note that with subjection to heat treatment, chromium causes sensitivity and even death in Euglena at concentrations lower than this legally acceptable level.

LEAD, CADMIUM, NICKEL, AND ZINC LEVELS IN EARTHWORMS AND MAMMALS RECOVERED NEAR HIGHWAYS OF DIFFERENT TRAFFIC VOLUMES. Charles W. Blair\*, Patrick F. Scanlon, and Anne L. Hiller\*. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Earthworms were recovered at distances of 3, 6, 12, 24 and 48 m from highways with traffic volumes of approximately 100,000, 24,000, 7,500, and 525 vehicles per day and from 2 control areas during 4 collection periods throughout 1976 and 1977. Small mammals were trapped within a 24 m zone of all highways and in both control areas during the same collection periods. Significant ( $P < 0.001$ ) differences between areas were seen in levels of lead, cadmium, and zinc in earthworms. There were significant ( $P < 0.05$ ) differences between distances from highways in cadmium and zinc levels of earthworms. There were no differences between sampling periods in levels of elements in earthworms. There were significant ( $P < 0.001$ ) differences between areas in lead levels of small mammals. Significant ( $P < 0.001$ ) differences between species of small mammals were found in cadmium and zinc levels. Shrew species (*Blarina*, *Cryptotis*, and *Sorex*) tended to have higher levels of all elements than *Microtus* or *Peromyscus*. [Supported by DOT Contract OS-60175].

HABITAT UTILIZATION BY *PEROMYSCUS LEUCOPUS* AND *BLARINA BREVICAUDA* OF AN APPALACHIAN FOREST IN SOUTHWESTERN VIRGINIA. B. Bliss, A. R. Tipton, R. Lochmiller and J. B. Whelan, Department of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061

Habitat utilization of small mammal populations was studied in two forest types-cove hardwood and mixed oak-pine. The tree, shrub and herb strata, and non-botanical environmental data were collected on a total of 166 plots in June and July 1977. In August 1977 trapping was conducted on each of the 166 plots for 18 consecutive days for collection of small mammals. Differences in the environmental parameters, as well as trap success for the two species, in the two habitat types were apparent. Regression tests were run using the small mammal trapping data and 125 environmental variables. In the mixed oak-pine habitat the occurrence of *Peromyscus leucopus* was highly correlated with the variance of the percent bare soil in each plot, and the number of shrubs in the 2-3 m height class. However, in the cove hardwood habitat the occurrence of *P. leucopus* was correlated with the heterogeneity index of the tree stratum and the height of the dominants in the herb stratum. The occurrence of *Blarina brevicauda* in the mixed oak-pine habitat was correlated with the percentage of the tree stratum in the 11-14 m height class and the mean percent cover of the shrub stratum that is evergreen. In the cove hardwood habitat, the occurrence of *B. brevicauda* was correlated with the basal area of the dead timber in the tree stratum and the percentage of the shrub stratum in the 2-3 m height class.

RESPONSE OF UNDERSTORY VEGETATION AND FOREST WILDLIFE TO COMMERCIAL THINNING. W. R. Bonwell, A. R. Tipton, J. B. Whelan and T. L. Sharik, Department of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061

Three mixed oak stands were thinned 1 per year for three years. Seven vegetation parameters were measured and white-tailed deer, gray squirrel, small mammal, and songbird populations were surveyed. Commercial thinning and the age since thinning has a decided affect on wildlife utilization of the sites. Preliminary findings indicate that small mammal and songbird populations increased two and three years after thinning. Gray squirrel populations in the Spring of 1977 were 2.62 per acre in an unthinned stand and no squirrels were found in the thinned stands. White-tailed deer were difficult to survey but there is an indication that deer preferred stands 1 and 2 years after thinning.

CRYSTALLOIDS ASSOCIATED WITH A PARASITE IN THE BLOOD CELLS OF *NATRIX SIPEDON SIPEDON*. Katherine A. Booker and William H. Yongue, Jr. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Snakes of the species *Natrix sipedon sipedon* were captured during the years 1976-1977 in the state of Michigan. A parasite, *Toddia bufonis* Franca, was found occurring naturally in 8 of 15 snakes. When stained with giemsa, *Toddia* exhibits a basophilic staining body and a crystalloid body in infected erythrocytes and polychromatic cells. Snakes can be mechanically infected by intraperitoneally injecting an aliquot of infected blood suspended in 0.65% saline. Progression of the parasitemia can then be followed. The crystalloids initially appear as amorphous bodies about eight days following inoculation. These gradually change to cuboidal forms over a period of about two weeks. These crystalloids are soluble in hot hydrochloric acid but are not soluble in ethanol or water; they are non-birefringent under polarized light.

OVULATION UNDER LABORATORY CONDITIONS IN PRAIRIE DEERMICE (*PEROMYSCUS MANICULATUS BAIRDII*). E. L. Bradley and C. R. Terman. Lab. Endocrinology and Population Ecology, Biology Department, College of William and Mary.

This study was designed to determine if ovulation in *Peromyscus maniculatus bairdii* is induced or spontaneous and to determine the accuracy with which vaginal smears reflect the ovarian cycle. Ovarian histology, vaginal smears and serum LH concentrations were compared among females inseminated 30 minutes or 24 hours previously or housed alone.

The results demonstrated that deer mice most frequently copulate in the dark period of their daily light cycle and that they have variable vaginal smear patterns. Ovulation was spontaneous in the absence of tactile contact with the male and was not consistently related to the time of copulation. Serum LH values were indicative of a preovulatory surge. This study also demonstrated marked variability among *P. m. bairdii* vaginal smear patterns, ovarian histology and plasma LH concentrations -- and their interrelationships. This variability may be due to the genetic heterogeneity of these wild animals and care should be taken in extrapolating to these animals findings obtained from studies of inbred laboratory mice (*Mus musculus*).

KEPONE RESIDUES IN BODY TISSUES OF RACCOONS COLLECTED ALONG THE JAMES RIVER, EAST OF HOPEWELL, VIRGINIA. C. P. Bryant, R. W. Young and R. L. Kirkpatrick. Depts. of Fisheries and Wildlife Sciences, and Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Five raccoons (*Procyon lotor*) were collected in box traps within 50 m of the James River and not more than 1 km below the mouth of Bailey's Creek in late August and early September 1977. This was approximately 2 years after the detection of extensive contamination of Bailey's Creek and the James River with Kepone from a chemical manufacturing plant. Four additional raccoons were trapped at Camp Pickett, Va. during the same time span for comparative purposes. Samples of brain, liver, and adipose tissue from all animals were collected, frozen and later analyzed for Kepone residues. Kepone was confirmed by mass spectrophotometry. Mean levels ( $\pm$ S.E.) of Kepone in tissues of animals from the James River area and Camp Pickett, respectively, were as follows: Brain 0.026 $\pm$ .001 and 0.001 $\pm$ .001 PPM; Liver 0.093 $\pm$ .110 and 0.006 $\pm$ .003 PPM; Adipose tissue 0.018 $\pm$ .009 and 0.001 $\pm$ .001 PPM. Although in all instances mean residues in animals from the James River area were several times greater than those from Camp Pickett, concentrations were always substantially less than 1 ppm. It does not appear, therefore, that Kepone from the James is entering the resident raccoon population to any appreciable extent.



A CLADISTIC APPROACH TO THE EVOLUTIONARY HISTORY OF SOME MAZOCRAEID TREMATODES. A. J. Butt\*. Inst. of Oceanography Old Dominion Univ., Norfolk, Va. 23508

Cladistic inferences of the genera Grubea and Neogrubea are analyzed to determine patterns of dispersal and vicariance. The mazocraeids are primarily parasites of Clupeiformes. These fishes underwent considerable evolution during the Cretaceous giving rise to the Perciformes. A first analysis of the separation of Grubeinae and Neogrubeinae ancestors probably occurred during the later Cretaceous to early Eocene with the rise of their hosts, the Perciformes. Examination of their distribution suggests different centers of speciation for each genus. Grubea species parasitize scombrids in northern latitudes whereas Neogrubea species are found on stomateoid fishes in the southern latitudes. A second analysis of cladistic relationship of Neogrubea species shows vicariance due to allopatric speciation of host species during the Tertiary.

PRELIMINARY STUDIES OF DIGESTIBILITY OF GRASS AND FORB DIETS BY PINE VOLES. S. L. Caturano\*, R. L. Kirkpatrick, and M. H. Merson\*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Previous field studies have indicated that pine voles (Microtus pinetorum) in different habitats can subsist on diets composed primarily of either grasses or forbs but that digestible energy intake is greater for voles living on grass diets (Estep et. al. 1975. Va. J. Sci. 26(2): 54). The present study was a first attempt to determine apparent digestible energy of naturally occurring forages under controlled laboratory conditions. Eighteen live-trapped adult pine voles were assigned one of the following diets: (1) orchard grass (Dactylis glomerata) and apple fruit; (2) dock (Rumex cf. obtusifolius) and apple fruit. Apple fruit was made available because previous work had indicated that voles could not maintain themselves on pure grass or forb diets in the lab. Average dry matter consumption per day for voles fed grass and apple was 1.25 g and 2.53 g, respectively and 0.75 g and 2.44 g, respectively for voles on the dock and apple diet. Average percent digestible energy was 87% and 94% for orchard grass and apple and dock and apple, respectively. The body weight changes were 0.48 g and 0.28 g for voles fed grass and apple and dock and apple respectively. There appeared to be little difference in digestibility of the forb and the grass by pine voles in this pilot study.

GENETIC CONTROL OF RESISTANCE TO AFLATOXIN B<sub>1</sub> TOXICITY IN DROSOPHILA MELANOGASTER. J. P. Chinnici, R. Hutchings\*, W. Payne\*, and A. Worthington\*. Dept. of Biology, Virginia Commonwealth Univ., Richmond, Va., 23284

The effect of continuous growth on media supplemented with either 0.35 or 0.70 ppm aflatoxin B<sub>1</sub> (AFB<sub>1</sub>), a potent insect toxic agent and vertebrate hepatocarcinogen, is reported for egg-pupa development time, egg to adult viability, and adult body length. Five strains of Drosophila melanogaster were studied: Lausanne-S (A-11, a "resistant" strain showing relatively little effect from AFB<sub>1</sub> treatments), Florida-9 (A-9, a strain very sensitive to the toxic effects of the AFB<sub>1</sub> treatments: elongated development time, reduced viability, and smaller adult body length) and three strains produced by chromosomal substitution from A-11 and A-9, testing the effect of chromosomes X (strain RX), 2 (strain R2), or 3 (strain R3) from A-11 against an A-9 background. Data from RX, R2, and R3 indicate that a polygenic system controls the ability of strain A-11 to resist the toxic effects of AFB<sub>1</sub> ingestion during larval development, with the greater effects being exhibited by the autosomal loci.

CHANGES IN PRODUCTIVITY OF FOOD FOR WHITE-TAILED DEER AND WILD TURKEY FOLLOWING A FOREST THINNING OPERATION IN THE RIDGE AND VALLEY PROVINCE OF VIRGINIA. D. W. Carlile, A. R. Tipton, J. B. Whelan, and T. L. Sharik, Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061

Three adjacent parcels of mixed oak forest in the Ridge and Valley Province of Virginia were thinned, one per year over three consecutive years. Following the thinnings, food plants preferred by deer and turkey were collected seasonally from the thinned parcels and a nearby unthinned parcel, using a 100 percent clip technique. Samples were weighed to yield estimates of food availability (Kg/ha) on the various parcels. At the first sampling period (Summer 1976), the three thinned parcels (A,B, and C) were in the third, second and first growing season after thinning. At the final sampling period (Spring 1977) the three parcels had begun the fourth, third and second growing seasons. Availability of a combination of three preferred foods, galax (Galax aphylla), teaberry (Gaultheria procumbens), and blueberry (Vaccinium vacillans) varied with season and treatment. There was no significant difference in food availability between the unthinned parcel and parcel B or between parcel A and C for all four seasons. There was also no significant difference between the thinned and unthinned parcels for the summer. Availability of food in the thinned parcels was significantly greater than in the unthinned parcel only during the winter on parcel A and during the spring and winter on parcel C.

TOXIC EFFECTS OF AFLATOXIN B<sub>1</sub> ON VARIOUS LARVAL STAGES OF GROWTH IN DROSOPHILA MELANOGASTER. J. P. Chinnici, M. Charnock\*, L. Erlanger\*, M. Jones, and J. Stein. Dept. of Biology, Virginia Commonwealth Univ., Richmond, Va., 23284

Using Drosophila melanogaster, those periods during larval development relatively more sensitive to the toxic effects of growth on media supplemented with 0.44 ppm or 0.88 ppm aflatoxin B<sub>1</sub> (AFB<sub>1</sub>) were determined. Two strains of fruit flies were tested: strain A-11 which is relatively more resistant to AFB<sub>1</sub> induced toxicity and strain A-9 which is quite sensitive. Eggs, mid-first, mid-second, and early, mid and late third instar larvae were transferred onto AFB<sub>1</sub> media and allowed to complete larval and pupal development and eclose as adults. Results show that strain A-9 larvae of the first, second and early third instar stages grown on 0.88 ppm AFB<sub>1</sub> diets display significantly higher mortality rates and smaller body lengths than controls; development times were elongated only if first instar larvae were exposed to AFB<sub>1</sub>. Comparison of strains shows that A-9 displays higher mortality rates than A-11 during first instar larval exposure to 0.88 ppm AFB<sub>1</sub> where both strains are affected and, in addition, strain A-9 is affected during the second and early third instar stages when strain A-11 is not affected at all.

PROGESTIN LEVELS DURING PREGNANCY IN THE CHINCHILLA. Elizabeth A. Coffin\*, Ann L. Hiller\*, Patrick F. Scanlon, and Francis C. Gwazdauskas. Departments of Fisheries and Wildlife Sciences, and Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Adult female chinchillas (Chinchilla laniger) were joined with males and blood samples were collected at two-weekly intervals until after parturition. Blood plasma was assayed for progestins by competitive protein binding assay. Data on progestin levels were analyzed by stage of pregnancy. The length of gestation was considered to be 112 days (Asdell S. A., Patterns of Mammalian Reproduction, Cornell University Press, 1964) and time of conception was estimated on this basis. Progestin levels before initiation of pregnancy were less than 10 ng/ml. Progestin levels were less than 10 ng/ml during the first trimester of pregnancy. They were very high during the second and third trimesters of pregnancy. They ranged from 11 to 117 ng/ml but were generally between 20 and 80 ng/ml. Progestin levels declined rapidly in the 2 weeks prior to parturition.

A COMPARISON OF MICROSCOPIC TO MACROSCOPIC COUNTS OF LUTEAL GLANDS IN THE GRAY SQUIRREL. C. J. Cowles\* R. L. Kirkpatrick and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, V.P.I. & S.U., Blacksburg, Va. 24061

A total of 108 adult and subadult female gray squirrels was collected over a period of one year from December 1966 to November 1967 in the vicinity of Blacksburg, Va. Immediately after collection, the number of luteal glands on the ovaries as determined by macroscopic examination was recorded. The ovaries were fixed in Bouin's solution and embedded in paraffin. Later the ovaries were serially sectioned, stained, and permanently mounted. A total of 73 luteal glands was detected microscopically on the ovaries of 24 animals. The previous macroscopic examination had only detected 46 luteal glands on the same ovaries, 63 percent of the microscopic total. Many of the luteal glands which had gone undetected in the macroscopic count were on ovaries of lactating animals.

Biologists often rely on macroscopic counts of luteal glands as productivity indices for this and other game species. It is not unusual for lactating squirrels to be found during early or late season bag checks; consequently error could occur frequently. It is recommended that microscopic counts using stained ovarian sections be made for this type of productivity estimate in the gray squirrel.

EFFECTS OF ADMINISTRATION OF EXOGENOUS HORMONES ON CAPTIVE FEMALE GRAY SQUIRRELS. C. J. Cowles\* R. L. Kirkpatrick, and P. F. Scanlon. Dept. Fish. and Wildl. Sci., V.P.I. & S.U., Blacksburg, Va. 24061

Two experiments were conducted on 19 adult female gray squirrels enclosed in indoor laboratory cages. In Experiment I, 4 groups of 3 animals received injections for 7 consecutive days followed by a final administration on the 13th day. Group 1 received saline on all days. Two mg FSH-P daily and subcutaneous injection of saline on the 13th day was received by Group 2. Group 3 received 2.0 mg FSH-P daily and 400 IU HCG subcutaneously on day 13. Group 4 differed from Group 3 only in that the HCG was received intravenously. In Experiment II, Group 1 (3 animals) and Group 2 (2 animals) received 200 µg FSH-P or NIH-FSH, respectively, on 7 consecutive days accompanied by 200 IU HCG on day 5. Group 3 (2 animals) received 2.0 mg FSH-P for 7 consecutive days followed by 200 IU HCG on day 13. Animals were sacrificed the day after the last injection. Results of Experiment I indicated that FSH-P alone was sufficient to luteinize tertiary follicles; no significant differences were observed between Groups 3 and 4. Results of Experiment II indicated that NIH-FSH will not luteinize tertiary follicles, probably due to absence of LH contamination. Group 3 of Experiment II had significantly more luteinized follicles than Group 2. Since most luteinized follicles contained entrapped ova in both experiments, successful induction of ovulation generally was not achieved.

IMPACT OF NON-POINT POLLUTION ON BENTHIC INVERTEBRATES IN THE LYNNHAVEN RIVER SYSTEM. II. GENERAL CONCLUSIONS. D. M. Daur, W. W. Robinson, C. P. Seymour, and A. T. Leggett, Jr., Dept. Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508

The information collected on the growth of oysters clearly indicates that within the areas studied in the Western and Eastern Branches of the Lynnhaven there was no significant deterioration of water quality.

The benthic infaunal macroinvertebrate communities of the Lynnhaven are dominated by a group of highly euryhaline opportunists naturally adapted to withstand environmental stresses. Examination of the spatial and temporal distribution patterns of individual species and comparison with samples collected in Old Plantation Creek lead to the conclusion that the amount of stress placed upon the environment of the Lynnhaven system by non-point discharges probably has little or no influence upon the natural benthic invertebrate populations.

ECOLOGICAL SURVEY OF A RAPPAHANNOCK RIVER LOW SALINITY MARSH. Debra E. Davis. Dept. of Biology, Mary Washington College, Fredericksburg, Va. 22401

This was a preliminary survey of the Island Farm marsh located on mile 43 of the Rappahannock River in Richmond County. Chemical, physical, and biological data was collected every week from October 11th thru November 27th. Two stations were set up in the marsh and samples were collected at each station. Station I was located near the river and Station II was located approx. 1/2 mile from the river into the interior of the marsh.

The data collected was considered normal for the area except for the high salinity of 10 ppt. and the finding of the sea squirt. The most puzzling aspect was that no snails were found. Reasons for this will be investigated during the year study starting in June, 1978.

INTRASPECIFIC CROWDING INFLUENCE ON THE DEVELOPMENT OF *MEGASELIA SCALARIS* (LOEW) (DIPTERA: PHORIDAE). P. F. Dowd\* and R. L. Pienkowski, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

*Megaselia scalaris* is a highly adaptable phorid since it is able to utilize a number of food sources. However, it, like other organisms, is subject to density dependent limitations. This study was designed to investigate the effects of intraspecific competition.

Four replicates of each density of 2, 5, 10, 25 and 50 larvae of the same age per 5 ml. of *Drosophila media* were held at 20-25°C and a 12-12 photoperiod. Larval and pupal development rates were noted, as was mortality.

Larval development rate at the highest density was significantly longer than that of the other densities, except the lowest one. Pupal mortality at the highest density was much greater than at the other densities. Additional observations also indicated that intraspecific crowding affected the vigor of the population at the highest density.

INTERSPECIFIC ADULT COMPETITION: INFLUENCE OF *DROSOPHILA MELANOGASTER* (DIPTERA: DROSOPHILIDAE) ON *MEGASELIA SCALARIS* (LOEW) (DIPTERA: PHORIDAE). J. G. Fairservice\* and R. L. Pienkowski, Dept. of Entomology, VPI & SU, Blacksburg, VA 24061.

In a study by Barker (1972) it was concluded that by increasing the densities of *D. melanogaster* and *D. simulans*, the average number of progeny per female decreased. It was noted that the cause of the *D. melanogaster* reduction was a decreased immature stage viability and the cause of the *D. simulans* reduction was decreased fecundity.

Five petri dishes containing *Drosophila media*, yeast, and water were set up. Two newly emerged *M. scalaris* females and 2 males of unknown age were introduced into each container. *D. melanogaster* were introduced to yield the ratios (*D. melanogaster* to *M. scalaris*) of 0:1, 1:1, 2:1, 3:1, and 4:1. Daily counts of eggs laid were tallied. The test was replicated twice.

The first replication laid 131, 187.5, 284.0, 89.5, and 160.0 eggs per female for the 0:1, 1:1, 2:1, 3:1, and 4:1 ratios. The second replication laid 297.5, 74.5, 168.0, 278.0, and 229.0 eggs per female for their respective ratios.

In conclusion there was no apparent behavioral response of *M. scalaris* to crowding by *D. melanogaster* as was noted in Barker's study on *D. simulans*.



THE EFFECT OF ALTOCID, A JUVENILE HORMONE MIMIC, ON A NON-TARGET INSECT, *NASONIA VITRIPENNIS* (HYMENOPTER : PTEROMALIDAE). Norman J. Fashing, Dept of Biology, Col. of William and Mary, Williamsburg, Va. 23185.

Insect Growth Regulators have been studied intensively in recent years since they appear to fit the requirements for third generation pesticides. Two few studies, however, have been conducted to establish their effects on non-target insects such as parasitic wasps. The present study evaluated the effects of Zoecon Corporation's juvenile hormone analog (JHA) Altosid SR-10 (methoprene) on the dipteran pupal parasite *Nasonia vitripennis*.

Topical application of Altocid (1 pt/1000 in distilled water) to prepupae and pupae of *N. vitripennis* resulted in 100% mortality during the pupal stage. However, when the compound was administered via its dipteran host *Sarcophaga bullata*, no effect could be found. To determine this, larvae were reared on a diet of ground beef liver containing JHA (1 pt/1000 by weight). Distilled water was substituted for JHA in controls. Treated and control pupae were exposed to wasps <48 hr. old and allowed to be parasitized. The experiment was replicated twice. A Two-Way ANOVA indicated that the number of adult wasps emerging from JHA treated pupae did not differ significantly ( $p=.62$ ) from the number emerging from controls. In another experiment it was found that the fecundity of wasps reared on JHA treated pupae did not differ significantly ( $p=.99$ ) from controls.

It appears that although Altocid SR-10 has a disastrous effect on *N. vitripennis* when applied directly on pupae, it has no effect when administered via its host.

INTERSPECIFIC LARVAL COMPETITION: INFLUENCE OF *DROSOPHILA MELANOGASTER* (DIPTERA: DROSOPHILIDAE) ON *MEGASELIA SCALARIS* (LOEW) (DIPTERA: PHORIDAE). J. M. Ferguson\* and R. L. Pienkowski. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061.

An experiment was conducted to determine the effects of differing densities of a larval competitor (*D. melanogaster*) on the development rate of larvae of *M. scalaris*. Five densities were used (including an all-*M. scalaris* control). The numbers of *D. melanogaster* in the treatments were 0, 1, 2, 4, and 8 times the number of *M. scalaris*. The experiment was initiated with eggs of both species and continued until all *M. scalaris* larvae had pupated. The data were analyzed as the number of days occurring from egg to the presence of a puparium for each insect.

It was found that high numbers of competitors (4X & 8X) resulted in no development whatsoever of *M. scalaris*. It is thought this may be due to the presence of waste products and/or allomones. At lower densities (1X-2X), the rate of *M. scalaris* larval development actually increased. The 1X and 2X treatments were significantly different from the 0X control, but not significantly different from each other.

A PRELIMINARY REPORT ON THE *EUMESOCAMPA* (INSECTA: DIPLURA: CAMPODEIDAE) OF NORTH AMERICA. Lynn Milton Ferguson\*. Dept. of Natural Sciences, Longwood Col., Farmville, Va. 23901

Two, or possibly three, species belonging to the campodeid genus *Eumescampa* have been described from North America. *E. danielsi* and *E. lutsi* Silvestri are endogeans known from north central Colorado. The third endogean species which apparently belongs to the genus is *E. frigidilla* (Hilton). This species has been found in New York, Pennsylvania, Ohio and Maryland. Two other species, one of which is found outside North America, have been proposed for inclusion in the genus; however, such an action does not appear justifiable.

The examination of over 300 campodeid collections from North American caves has revealed two new species of *Eumescampa*. One species has been found in six caves of Jefferson, St. Genevieve, and Perry counties of Missouri, and in six caves of Pike, Monroe, and Union counties of Illinois. The caves are in similar limestone strata exposed on both sides of the Mississippi River. The other hypogean species was collected in Steeles Cave, Monroe Co., West Virginia, where it is sympatric with *Plusiocampa fieldingi* Condé. This undescribed species is closely related to an endogean *Eumescampa* sp. that I have identified from Albany Co., New York. The latter species is probably *E. frigidilla*. There is a distinct difference between the dorsal thoracic chaetotaxy of the eastern species and the mid-western and western species.

A STUDY OF THE MACROBENTHIC COMMUNITY OF HAZEL RUN, SPOTSYLVANIA COUNTY, VIRGINIA. Penelepe L. Firth and Michael L. Bass, Dept. of Biology, Mary Washington Col., Fredericksburg, Va. 22401

A seven month study of the benthic macroinvertebrates of Hazel Run, Spotsylvania County, Virginia, was carried out from September, 1977 to March, 1978. Eight sampling locations were spaced along the length of the 13 km. stream from the headwaters to the mouth where it enters the Rappahannock River at Fredericksburg. The nature of the substrate was a determining factor affecting the distribution and density of the invertebrates. Species diversity was used as a tool to determine the effects of flooding and siltation on the stream community. Flooding resulted in washout in several areas of the creek, lowering species diversity and abundance in February, 1978. Siltation also lowered species diversity and abundance in a limited section of the stream near construction of the housing development Sheraton Hills East. Inputs to the stream include periodic overflow sewage from a sewage pumping station and drainage from a fertilizer plant- stockyards industrial complex. No conclusive evidence indicates that nutrient loading is having harmful effects on the macrobenthic community.

EFFECTS OF DOMINANCE-SUBORDINATION INTERACTIONS ON URINE MARKING PATTERNS OF MALE PRAIRIE DEERMICE (*PEROMYSCUS MANICULATUS* BAIRDII). Kathleen A. Funk and C. R. Terman. Lab. Endocrinology and Population Ecology, Biology Department, College of William and Mary.

Urine marking was measured in pairs of male deermice in the following two situations: one where the pair was separated by a wire partition, and another where the pair was again separated by a wire partition after two one hour encounters occurring on successive days. Encounters in a neutral arena allowed the pair to fight and establish a dominant-subordinate relationship. In each of these situations, Whatman Number One filter paper was placed under the marking apparatus. When examined under UVL-50 black light, urine marks will fluoresce a bright blue. In this way urine marking patterns can be distinguished. It was found that the amount of pooling and spraying done by a particular animal depends on social rank. Dominant males spray the floor of their cage, but pool very little. Subordinate males show the opposite effect. *P. m. bairdii* deposits urine in patterns similar to but not identical with *Mus musculus* patterns.

IRON-59 UPTAKE AND DISTRIBUTION IN AFLATOXIN B<sub>1</sub> AND COPPER TREATED MONGOLIAN GERBILS *Meriones unguiculatus*. C. Gomer\*, S. C. Shafer, and G. C. Llewellyn. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23220

Recent reports in the literature indicate the toxic and carcinogenicity effects of aflatoxin B<sub>1</sub> on various animals. Each of four groups of adult male Mongolian gerbils received one of four diets for a period of 22 days: control; 0.5% copper acetate; 10 ppm aflatoxin B<sub>1</sub>; 0.5% copper acetate and 10 ppm aflatoxin B<sub>1</sub>. Individual animals received 12.5 uCi of <sup>59</sup>Fe-ferrous citrate on day 18. Control animals showed a 24% increase in mean body weight; animals receiving copper acetate, 4%; animals receiving aflatoxin, 1%; and animals receiving copper acetate and aflatoxin, a 9% increase. Percent <sup>59</sup>Fe retention for whole body counts for days 18-22 were: 8.55, 3.24, 2.21, and 2.11 for control; 20.25, 7.35, 3.23, and 2.96 for copper acetate; 14.30, 5.27, 2.72, and 1.88 for aflatoxin; and 15.60, 4.67, 2.38, and 2.27 for copper acetate and aflatoxin. Retention of the radioisotope in organs was as follows: duodenum > blood > liver > lung > kidney > spleen. Aflatoxin treatment appeared to reduce the counts in the blood whereas combined aflatoxin and copper treatments were not reduced to a similar degree. Liver counts were not significantly different.



HEAVY METAL ACCUMULATION BY THE ASIATIC CLAM (*CORBICULA MANILENSIS*) FROM FIELD COLLECTIONS AND LABORATORY BIOASSAYS. R. L. Craney\*, J. H. Rodgers, Jr.\*, D. S. Cherry\*, K. L. Dickson, and J. Cairns, Jr. Center for Environmental Studies-Biology Dept., V.P.I. & S.U., Blacksburg, Va. 24061

The Asiatic clam (*Corbicula manilensis*) has recently been established in the New River at the vicinity of the Glen Lyn Power Plant, Giles County, Virginia. Samples of water, sediment, clam visceral mass and shells from above, below, and within the thermal discharge were analyzed for copper and zinc accumulations by atomic absorption spectrophotometry. Mean concentrations of Cu and Zn, respectively, were lowest in the river water ( $\leq 0.01$  ppm), intermediate in sediments (13 to 50 ppm) and highest in clam tissue (210 to 334 ppm). Concentrations in clam shells varied with Cu being generally greater than sediment accumulations and Zn being usually less. On a dry weight basis of visceral tissue, smaller clams were generally greater concentrators of heavy metals. In laboratory static bioassays in which test concentrations ranged from 0.005 to 10.0 ppm, heavy metal concentrations were consistently higher in both tissue and shell samples when exposed to 5 and 10 ppm for 24 hours. Accumulations in clam samples at lower concentrations showed no appreciable uptake and were similar to concentrations measured in clams taken from the river. Filtering ability diminished considerably when test solutions of Cu and Zn reached 5 ppm which indicated a potential stress threshold to these toxicants. (Aided by OWRT Grant B-101-VA)

TISSUE CULTURE OF THE MONOCOTS *LILIU*, *HEMEROCALLIS*, AND *HIPPEASTRUM*. R.H. Graves\*, and M.C. Mathes\*. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

A procedure for *in vitro* propagation of *Lilium regale*, *Hemerocallis*, and *Hippeastrum* varieties was established. Dormant bulbs provided sources of tissue for *Lilium* and *Hippeastrum* cultures; scape tissues were used for *Hemerocallis* cultures.

*L. regale* explants produced bulblets and callus on basal medium and on various IAA-kinetin supplemented media. 2,4-D inhibited bulblet formation, but promoted callus growth.

*Hemerocallis* explants did not grow on basal medium, but demonstrated good morphogenetic potential on IAA-kinetin supplemented media. 2,4-D induced root and callus growth.

*Hippeastrum* explants produced bulblets on basal medium and IAA-kinetin supplemented media. Callus was observed, but was neither friable nor separable from the explants. 2, 4-D induced prolific root growth with an occasional bulblet.

The influence of the auxin-cytokinin ratio upon the organogenic potential of explants was investigated. *L. regale* and *Hippeastrum* explants were not influenced by auxin-cytokinin manipulations. However, *Hemerocallis* explants responded classically by producing shoots on high kinetin medium and roots on high IAA medium.

Cold treatments were given to plantlets to induce dormancy and facilitate their establishment in soil.

THE CHIRONOMIDAE (DIPTERA) OF A NEW RESERVOIR. T. N. Grimes\*, J. R. Voshell, Jr., and G. M. Simmons, Jr. Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

The purpose of this study was to analyze the successional changes which occurred in the chironomid fauna of a new reservoir. This study was conducted in Lake Anna, Louisa Co., VA, during the first 3 years after the impoundment of the North Anna River (1972-75). The reservoir was immediately colonized by chironomids and the densities increased successively in each of the first 3 years. *Glyptotendipes* was the most common genus throughout the study. *Dicrotendipes* and *Endochironomus* were common the first year but became scarce the second year when other taxa became abundant. These included *Procladius*, *Tanytarsini*, *Ablabesmyia*, *Chironomus*, and *Cryptochironomus*, in order of decreasing abundance. There were no major changes in the composition of the chironomid fauna the 3rd year. A review of the autecology of the major genera involved revealed that the major factors determining the successional changes were probably the allochthonous organic matter present in the basin at impoundment and the development of the planktonic communities in the lentic ecosystem. The changes in the chironomid fauna are also compared to the general concept of succession and certain aspects of the theory of island biogeography (K-selection vs. r-selection).

THE EFFECTS OF ROTENONE ON THE MACROBENTHIC INVERTEBRATES OF A PENNSYLVANIA STREAM. L. A. Helfrich\*, Dept. of Fisheries & Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Although the use of rotenone as a fish toxicant is a common freshwater fisheries management technique, little is known of its effect on stream invertebrates. Sinking Creek, a small cool-water stream located in central Pennsylvania, was treated with approximately 1 p.p.m. of 5 percent rotenone. Pre and post-treatment bottom samples of benthic invertebrates, collected from four study stations, were compared to determine the short-term effects of rotenone. Continuous drift samples collected throughout the treatment period provided additional quantitative and qualitative information on the vulnerability of the benthic invertebrates to the toxin.

Of the four major orders of macrobenthic invertebrates represented in Sinking Creek (Trichoptera, Ephemeroptera, Plecoptera, and Diptera), all exhibited substantial decreases in numerical abundance eleven days after rotenone treatment. Densities of Plecoptera (stoneflies) and Diptera (blackflies and midge larvae) were severely reduced, while densities of the two remaining taxa, Trichoptera (caddisflies) and Ephemeroptera (mayflies) were reduced by about 50 percent. All four orders appeared in increased numbers in the drift samples taken during the treatment period.

SURVIVAL AND LONGEVITY OF WOODMICE FOLLOWING CUTEREBRID LARVAL PARASITISM. M. S. Hensley. Div. of Natural Science, Paul D. Camp Cmnty. Coll., Franklin, VA 23851.

Composite life tables were constructed for 66 spring cohort woodmice (*Peromyscus leucopus*) captured and aged during spring, 1974, on an insular 7 ha woodlot in upland Virginia. Mice were live-trapped throughout summer and fall, with particular attention paid to state and degree of parasitic infection by botflies (*Cuterebra fontinella*). Mean 14-dy survival ( $\ell_x$ ) for all mice was .701, with a mean longevity ( $e_x$ ) of 43 dy following onset of the bot season. Component analysis within the cohort revealed major bot-induced alterations in survivorship. Mice harboring single bots had significantly greater  $\ell_x$  (.803) and  $e_x$  (60 dy) values than "all mice" and "bot-free" components. However, severely-infected hosts (multi-infections or re-infections) suffered significantly reduced  $\ell_x$  (.477) and  $e_x$  (27 dy) values compared to all other classes.

Previous research on this population revealed that infected mice have shrunken home ranges, and that bots cause degeneration or dysfunction of host's gonads. I hypothesize moderately-infected hosts live longer because restricted range reduces the probability of predatory encounters, and because reduced fertility conserves more energy and potential survivorship than is lost to the parasite. In severely-infected hosts, all gains are cancelled by bot-induced debilitation.

LEAD, CADMIUM, NICKEL, AND ZINC LEVELS IN SOIL AND VEGETATION FROM ROADSIDES OF DIFFERENT TRAFFIC VOLUMES. Anne L. Hiller\*, Patrick F. Scanlon, and Charles W. Blair\*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Soil and vegetation were collected along four highways of different traffic volumes, at varying distances from the road, and at two control areas. Four sampling periods were conducted throughout the course of a year from August, 1976 to June, 1977. Soil and vegetation samples were tested for concentrations of lead, cadmium, nickel and zinc using atomic absorption spectrophotometry. There were general decreases in the concentration of lead, cadmium, nickel and zinc in roadside soil and vegetation as proximity to the highway decreased. Many of these declines were statistically significant ( $P < 0.05$ ) especially along the highways of greater traffic volume. Lead and zinc levels in roadside soil and vegetation exhibited a general decrease with decreasing traffic volume. There was not a strong relationship between the levels of cadmium and nickel in roadside soil and vegetation and traffic volume. A seasonal pattern existed in the levels of lead, nickel, and zinc in roadside vegetation, with plants from the February/March collection period exhibiting the highest levels. [Supported by DOT contract #0S-60175].



BIRD SPECIES UTILIZING PEANUT FIELDS IN EASTERN VIRGINIA  
Richard B. Hiller\* and Patrick F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Studies were conducted to determine what species of birds were utilizing peanut fields in Eastern Virginia because of the possible involvement of birds in the spread of a peanut disease. Twenty fields were observed monthly for a period of one year. Species, numbers per species, condition of field, stage of peanut crop, weather, and time of day were recorded for each observation period. A total of 28 species were observed utilizing peanut fields. The type of utilization varied among species, with the following activities being observed: resting, dusting, gathering various materials, feeding, seeking cover, nesting behavior, passage to adjacent areas, or brief visits to the periphery of fields. Feeding activity was most common, with insects, waste peanuts, seed peanuts, drying peanuts, and possibly foliage as attractants. The total number of birds observed utilizing peanut fields was lowest during July, and highest during late October due to large flocks of blackbirds which were present following digging of the peanut crop.

ANTIPREDATIVE FUNCTION OF THE GELATINOUS COATING OF THE EGGS OF THE FROG, *RANA P. PIPIENS* Schreber (Amphibia; Ranidae). W. Stanley Jennings, Jr. \* and G.C. Schaefer. Dept. of Biology, Univ. of Richmond, Va. 23173

The eggs of *Rana pipiens*, the northern leopard frog, were offered in several forms to *Lepomis macrochirus*, the bluegill. The fish were offered random trial discrimination tests while in groups of one or five in 40 l aquaria. *L. macrochirus* learned to make distinct discriminations and rejected fertilized and unfertilized egg masses, boiled egg masses, dried frog eggs and gelatin made with homogenized frog eggs. In contrast, Shrimp-el-etts, Shrimp-el-etts dyed black, gelatin made with peptone, and frog ovarian eggs were accepted readily. The results suggest a protective function for the gelatinous coat; both physical and chemical. The chemical is evidently added in the oviduct with the gelatinous coat, and is not affected by fertilization, desiccation or temperatures up to 100 C. Comparisons of these experiments with other studies suggest that the gelatinous coat is even more effective in discouraging predation by vertebrates in the field than it is in the laboratory.

EOSINOPHILIC MENINGOENCEPHALITIS IN MICE CAUSED BY *ANGIOSTRONGYLUS CANTONENSIS*. D. T. John. Dept. Microbiol., Va. Commonwealth Univ., Richmond, VA 23298.

Eosinophilic meningoencephalitis, a disease of the central nervous system of man, is caused by the rat lung-worm *Angiostrongylus cantonensis*. This report describes the histopathology for mice following a primary infection with *A. cantonensis*. Female Swiss mice aged 12-14 weeks were each infected perorally with 75 third-stage larvae. Histologic sections (H & E stained) were prepared from infected mice for 180 days after infection. Larvae appeared in the brain within 24 hours and tended to concentrate in the anterior cerebral hemispheres. During the next 10-15 days, larvae migrated in the brain tissue and moulted twice. Migrating larvae did not cause obvious tissue damage nor did they elicit a cellular response; however, discarded cuticles and dead larvae were surrounded by a cellular infiltration. After the final moult, worms migrated to the surface of the brain and appeared in the subarachnoid space. Worms remained there for many months provoking a severe acute inflammatory reaction consisting chiefly of eosinophilic polymorphonuclear leukocytes. Perivascular cuffing by chronic inflammatory cells occurred. Occasionally, worms were found in the ventricular system, within the choroid plexuses with inflammatory reaction. Granulomas occurred wherever worms died, usually on the surface of the cerebral or cerebellar hemispheres.

THE DISTRIBUTION OF *BAYLISASCARIS PROCYONIS* IN VIRGINIA. E. J. Jones\*, B. S. McGinnes\*, and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The intestinal tracts of 70 raccoons (*Procyon lotor*) collected from 11 counties in Virginia between December, 1976 and February, 1978 and were examined for the presence of the adult ascarid worm *Baylisascaris procyonis*. The larval stage of this ascarid is responsible for the disease cerebrospinal nematodiasis in lagomorphs and rodents. Of the 70 raccoons examined 21 animals harbored the adult worm. They occurred in Montgomery (17 of 19), Augusta (3 of 9), and Carroll (1 of 1). Animals were also examined from the counties of Page (1), Spotsylvania (1), Prince George (5), Nottoway (19), Botetourt (2), Giles (1), Lancaster (11), Northumberland (1).

The distribution indicates that this ascarid is confined primarily to the western, more mountainous portion of the state.

A SURVEY FOR TULAREMIA IN PIEDMONT VIRGINIA. E. J. Jones\*, B. S. McGinnes\*, and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Tularemia has been reported previously in the piedmont region of Virginia in the eastern cottontail rabbit (*Sylvilagus floridanus*) at Fort Pickett, Virginia (Jacobson, et al. 1975: Va. Acad. Sci. 26(2):56). A survey of mammals and bobwhite quail (*Colinus virginianus*) for the presence of tularemia antibodies was conducted from October, 1976 to February, 1978 by trapping and bleeding animals collected at Fort Pickett, Virginia. Serum collected was sent to the Commonwealth of Virginia's Division of Consolidated Laboratory Services for testing. Of 90 samples from 12 species tested 9 gave positive reactors (titer range 1:20 to 1:320). Species exhibiting positive titers were *Odocoileus virginianus* (1), *Mephitis mephitis* (1), *Rattus norvegicus* (1), *Colinus virginianus* (1), *Didelphis marsupialis* (1), and *Procyon lotor* (4). The positive titers were from animals collected between August 5, 1977 and September 10, 1977.

The high number of positive samples collected and the number of species from which they came indicate that there are many species that could act as reservoirs for the disease and that it could be responsible for the continued decrease in the number of cottontail rabbits harvested at Fort Pickett.

AGE STRUCTURE OF A COTTONTAIL RABBIT POPULATION IN PIEDMONT VIRGINIA. E. J. Jones and A. R. Tipton, Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061

There is a continuing decline in the number of eastern cottontail rabbits (*Sylvilagus floridanus*) harvested by hunters at Fort Pickett, Virginia. To establish the age structure of this population, eyelens were collected from hunter killed rabbits during 1976-77 and 1977-78 hunting season. Age was determined from lens weight using tables constructed by Edwards. Because it is impossible to determine the exact age of animals over one year of age, the population was divided into two groups, less than one year and over one year. It was found that 46% of the 54 animals from which eyes were collected in 1976-77 season and 58% of the 69 collected in the 1977-78 season were adults. These values are not statistically different. This high percentage of adults indicates that there is either a high incidence of yearling mortality or reduced reproduction. Mortality could possibly be due to the incidence of tularemia at Fort Pickett. In 1976 a distinct bimodal distribution of birth dates is found occurring in March and July whereas in 1977 a peak occurs in April with March and May also high. This may indicate that only one litter succeeded in 1977 and was late whereas in 1976 two litters were successful. Further examination of the age structure and meteorological data is needed.

BASIC STUDIES OF CHIASMA FREQUENCY IN MALE *BLATTELLA GERMANICA*. C. B. Keil\*. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061.

Chiasma frequency was estimated from squash preparations of testicular tissue of 3rd to 4th instar male cockroaches, *Blattella germanica*. Sufficient numbers of diplotene configurations, the most suitable stage of meiosis for counting chiasmata, may be found in this age nymph. Bivalents with two chiasmata form ring structures while those with single chiasma assume a rod configuration. Three chiasmata result in a "figure eight" but are rarely observed.

Pilot studies indicated observations from 55 cells per individual and 20 individuals per group were necessary to detect differences of one standard deviation.

Estimates of chiasma frequency were made from nymphs from the 1st ootheca of 50 VPI laboratory strain females. I found 1.343 chiasma per bivalent,  $\delta = 0.077$ . The total length of the autosomes calculated from this data is 738.4 map units, a mean of 67 units per bivalent.

Chiasma frequency of nymphs emerging from the 2nd and 3rd ootheca as well as nymphs from a translocation stock was examined to gain information related to possible cytogenetic compensatory mechanisms.

SUBSTRATE COMPOSITION AND PARTICLE-SIZE: THEIR INFLUENCE ON THE OCCURRENCE OF CHIRONOMIDAE AND CERATOPOGONIDAE (DIPTERA) IN THE LITTORAL ZONE. W.I. Knausenberger and E. C. Turner, Jr., Dept. Entomol., VPI&SU, Blacksburg, VA 24061

Few studies have been done on the substrate requirements of the immature stages of Chironomidae and Ceratopogonidae in the littoral zone. In connection with ecosystematic survey research on these midges, we made quantitative analyses of physical, chemical and vegetative characteristics of habitat substrates at over 500 sites throughout Virginia. The emphasis in this discussion is on the fauna of stream edges.

Sediment texture most relevant to midge distribution was represented by particle sizes ranging from pebbles to silt and clay (-3 to +4 in  $\phi$  units). Ceratopogonidae tended to occur in sediments with lower sorting coefficients (standard deviations) and smaller mean particle sizes than did Chironomidae. Ceratopogonidae were encountered chiefly but not exclusively in lentic subhabitats along the lotic system. Characteristic relationships between substrate type/chemistry and midge communities were not always discernible at the subfamily, genus and species levels, but useful generalizations can be suggested.

In addition to sediment character and texture, the following markedly influenced midge distribution: wind and wave action; current flow pattern; rhizosphere of adjacent terrestrial vegetation; periphyton; aquatic vegetation; and plant detritus (allochthonous and autochthonous). Species richness clearly reflected substrate diversity.

PRELIMINARY OBSERVATIONS OF THE LIFE HISTORY OF *HETEROCLOEON CURIOSUM* (McDUNNOUGH) (EPHEMEROPTERA: BAETIDAE). B. C. Kondratieff\*, and J. R. Voshell, Jr. Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

The life history and ecology of *Heterocloeon curiosum* (McDunnough) has been studied in the North Anna River, Hanover County, Va. from June 1977 to April 1978. The objectives of this study were to determine the duration and temporal distribution of the different life stages and the ecological factors affecting the spatial distribution of this species. Emergence of adults occurred throughout the summer. The average duration of the subimaginal stage ranged from 17 hours to 18 hours 30 minutes, averaging 17 hours 30 minutes. The nymphs were most abundant in fast-running riffles on the upper surfaces of large stones. A discussion of instar analysis in mayflies is also included.

HABITAT SEGREGATION BETWEEN TWO SYMPATRIC MICROTINE SPECIES (*MICROTUS PINETORUM* AND *MICROTUS PENNSYLVANICUS*). S. K. Kukila and A. R. Tipton. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State University, Blacksburg, Va. 24061

A one-year capture-recapture study of a pine vole (*Microtus pinetorum*) population in an abandoned apple orchard has also involved monitoring of a coexisting meadow vole (*Microtus pennsylvanicus*) population. From September 1977 to April 1978 four trapping sessions (8840 trap nights) have been conducted. A total of 181 individual pine voles and 44 individual meadow voles have been handled. The ground vegetation of the orchard is dominated by poison ivy (*Rhus radicans*) and scattered patches of Japanese honeysuckle (*Lonicera japonica*). Segregation of the habitat and a negative association between these two microtines has been evident. Of the total meadow vole captures, 75 percent have occurred in honeysuckle cover as opposed to only 5 percent of the total pine vole captures. Captures of both species has occurred at only five of the 164 trapping stations.

Recent studies have documented the occurrence of pine vole populations in areas dominated by honeysuckle which suggests that competition maybe the cause for habitat segregation in this orchard.

THE EFFECT OF TEMPERATURE AND FEEDING ON LONGEVITY, FECUNDITY, AND INTRINSIC RATE OF INCREASE OF *GRYON PARKERI*, AN EGG PARASITE OF THE LARGE AND SMALL MILKWEED BUGS. R. L. Lampman\* and N. J. Fashing. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185.

*Gryon parkeri* was reared on the eggs of *Oncopeltus fasciatus* and *Lygaeus kalmii* at three temperatures (24, 27 and 33°C) under fed (dilute honey solution) and unfed conditions. The mean length of life decreased with increasing temperature under each condition, but was approximately the same for wasps reared on different species of bugs for a given condition. Within a temperature, fed wasps lived approximately twice as long as unfed. Also, the fed groups had almost twice the mean number of progeny as the unfed at each temperature. At a specific temperature and feeding condition, the mean number of progeny was approximately equal for wasps reared on different species of bugs.

The intrinsic rate of increase ( $r$ ) (as calculated by a formula based on Birch, J. Anim. Ecol. 17: 16), increased with increasing temperature for feeding conditions as well as different species of bugs. The  $r$  values were consistently less in the unfed condition at all three temperatures. The  $r$  values were also consistently lower for wasps reared on *L. kalmii*.

APPLICATION OF MICROENZYMATIC TECHNIQUES TO THE ANALYSIS OF INDIVIDUAL HUMAN MAMMARY TUMORS. Elizabeth H. Lerner\* and Charles L. Rutherford, Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061

A microchemical technique has been adapted to evaluate the membrane-bound enzyme alkaline phosphatase within human malignant and benign breast lesions. Frozen tissue sections were either stained or lyophilized in alternating sequence in order that samples for enzyme analysis could be chosen from well defined regions of epithelial proliferation. Microgram quantities of human tumors could then be examined with multiple replications to elucidate patterns of overall enzyme activity, the activity of tissue fractions, and the isoenzyme form present within individual tumors. A significant decrease in enzyme activity was found for the malignant tumor group. The percentage of this activity found in 29,000 x g pellets of malignant tumors was variable and approximately 60% of the total activity found in all fractions, while that for benign tumors was more constant and approximately 90% of the total found. The malignant and benign tumor enzyme of both supernatant and pellet fractions was 90% labile to incubation at 65°C for 5 min and 50% inhibited by 20 mM L-phenylalanine. Polyacrylamide gel electrophoresis revealed a single enzyme band of identical  $R_f$  for each of these fractions from the two tumor types. Although co-incubation of different tumor samples had no effect on these parameters, a change in the proportion of activity pelleted was effected by sample cellularity.



MUSCLE SOUNDS - A TECHNIQUE FOR ANALYSIS. W. M. Lawson\* and M. A. Gordon. Dept. of Biology, James Madison Univ., Harrisonburg, Va. 22801

The perfection of two techniques for visualizing and recording contracting muscle fiber sound is presented. Muscles, stimulated electrically, produce distinctive sounds which are picked up by a microphone, amplified and recorded as physiograph or oscilloscope traces. The sartorius, gastrocnemius and pectoralis muscle sounds of *Rana pipiens* and *Rana catesbeiana* were compared and found to have similar diphasic waveforms. This diphasic waveform represents actual physical displacement of the muscle fiber which results in pressure changes that reach the microphone. Sound response occurred at the same frequency as the stimulus and increased in magnitude with the stimulating voltage. A minimal stimulus of one volt was required to produce a sound response on the oscilloscope. Sounds were found to occur at varying frequencies corresponding to different contraction rates in the muscle fibers. Sound production during relaxation was also recorded and a possible step-wise method of relaxation is suggested. Sound waveforms were consistently reproduced with a given stimulus and possible sound representations of summation phenomena were recorded. It is suggested that a microcomputer can utilize these muscle sounds when they are electronically converted into a digital form; this will allow computer analysis of the sounds. Additionally, microcomputer control of prostheses triggered by muscle sounds may be feasible.

ANALYSIS OF IMPINGEMENT AND FAR-FIELD FISHERIES DATA COLLECTED AT A SOUTH-CENTRAL RESERVOIR. B. E. Logan\*, M. T. Masnik and J. H. Wilson. US Nucl. Regulatory Comm., Washington, DC. 20555

Four years of impingement and far-field fisheries data were analyzed for an operating power station located on a south-central run of the river reservoir. *Dorosoma petenense*, *D. cepedianum*, *Ictalurus punctatus*, *Lepomis macrochirus* and several other recreationally or ecologically important species commonly found on the intake screens were chosen for comparison. Weekly estimates of impingement losses sustained by each selected species were determined for the four year period. Results of analysis of variance performed on the natural log transformed estimates indicate significant impingement trends between years. Results of the impingement analysis were compared and contrasted with far-field data collected throughout the reservoir.

OPTIMAL CONDITIONS FOR RAT LIVER RIBOSOMAL PROTEIN EXCHANGE. B.K. Mansfield, and Norman E. Garrison. Biology Dept., James Madison Univ., Harrisonburg, Va. 22801

Unfertilized eggs of some species have the cellular components necessary for protein synthesis, yet these eggs translate proteins at a minimal rate until after fertilization, at which time massive translation begins. A theory which attempts to explain pre-fertilization translational inactivity is that ribosomes are missing components (such as initiation factors) and that these ribosomes are rendered translationally functional after fertilization due to protein factor binding. It has been shown that fertilization causes the egg membrane to be more permeable to K<sup>+</sup> and other ions which results in a changing cytoplasmic environment. Perhaps the chemical conditions in unfertilized eggs are such that cytoplasmic protein factors do not bind to ribosomes, resulting in translationally inefficient ribosomes. Possibly due to the cellular chemical changes, the ribosomes are made functional by the binding of protein factors to them. In order to determine the extent to which the chemical environment affects the exchange of proteins between ribosomes and cell sap, rat liver ribosomes and cell sap were incubated with varied concentrations of ions and 2-mercaptoethanol, at different temperatures for varying periods of time. Such experiments correlating ribosomal protein exchange with chemical and ionic conditions may aid in establishing why developmentally significant proteins are not synthesized until after fertilization.

ENERGY FLOW THROUGH A RIPARIAN BREEDING BIRD COMMUNITY FOLLOWING STREAM CHANNELIZATION. R. L. Lochmiller\*, J. B. Whelan. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Energy flow and production were estimated for riparian breeding bird communities on channelized and unchannelized streams in the Roanoke Creek Watershed, Charlotte County, Va., in 1975 and 1976. Bird species diversity, species richness, number of breeding pairs, and standing crop biomass increased with increasing age since channelization. In 1976 the total adult energy demand (TAED) was 2.5 times greater on the unchannelized stream (27.3 Mcal/day/40ha) than on the 3-year old channelized site (11.26 Mcal/day/40ha). In 1975 TAED was 2.5 times greater on the 9-year old site (35.42 Mcal/day/40ha) than on the 2-year old site (14.72 Mcal/day/40ha). Total consumption of nestlings (TCN) during their growth period in 1976 was 490.91, 197.28, 229.36 and 114.05 Mcal/40ha on the unchannelized, 10, 6, and 3-year old channelized sites, respectively. In 1975 TCN was 651.58, 329.96, and 218.58 Mcal/40ha on the 9, 5, and 2-year old channelized sites, respectively. Converted to biomass the annual production in 1976 was 12.3, 24.7, 21.6, and 51.6 Kg/40ha on the unchannelized, 10, 6, and 3-year old channelized sites respectively. Annual production in 1975 was 23.2, 34.9, and 68.8 Kg/40ha on the 2, 5, and 9-year old channelized sites respectively. Community energy flow and production increased with ecological recovery from stream channelization.

COLOR DISCRIMINATION BY THE BOTTLENOSE DOLPHIN. C.J. Madsen\* and L.M. Herman\*. Dept. of Psychology, Univ. of Hawaii, Honolulu, HI. 96822.

Several experiments were performed with a bottlenose dolphin, *Tursiops truncatus*, to test its response to color. White and monochromatic lights of randomly varying intensities were presented in air while attempting to 'fade in' purity and wavelength discriminations from previously learned spatial and visual discriminations. In addition, relative thresholds were obtained for three monochromatic lights under various conditions. These thresholds were fitted by standard Darnall spectral sensitivity functions peaking at 495 nm for several sets of values obtained in low light conditions and at 500 nm for one set of values obtained at high ambient light intensity. Although human functions obtained in the same conditions were not perfect scotopic and photopic functions, it was concluded that the high-intensity function represented predominantly cone activity and the low-intensity function rod activity for the dolphin. Since the two functions were very similar and the earlier attempts to train purity and wavelength discriminations had failed, it is hypothesized that the cones function to extend the effective ambient light intensity range of the dolphin eye rather than for color vision.

TEACHING ELECTRON MICROSCOPY IN THE COMMUNITY COLLEGE--EVALUATION OF TEN WEEK COURSES. James H. Martin, Dept. of Biology, J. S. Reynolds Cmnty. Col., Richmond, Va. 23241.

A ten week course in electron microscopy has been offered at J. S. Reynolds Cmnty. Col. for the past year. The course is designed to give each student experience in the areas of fixation, dehydration, embedding, manual methods of trimming & glass knife making, thin sectioning, staining, use of the electron microscope, and photographic techniques necessary to produce EM prints. Students are required to supply a plastic box to hold their supplies, a pair of fine forceps, a glass cutter, and the text. All other materials are supplied by the College at a total cost of approximately \$120 per quarter for a class of 6 students.

Student backgrounds range from that of college freshman to Doctoral candidates (27% of the students hold Bachelor's degree or better). Students experience greatest difficulty in learning to thin section, and generally take most of the quarter to produce acceptable sections using a Porter-Blum MT-1 ultramicrotome located in the back of the classroom.

Successful operation of the electron microscope rarely requires more than 2 hours of supervised operating time. So far, only 2 students failed to successfully complete the course; therefore, we have had great success training undergraduates in electron microscopy. Since the difficulties have arisen only around the ultramicrotome, it is concluded that a newer model and a better location would facilitate more rapid training of students.



TRIASSIC FOSSILS IN THE RICHMOND BASIN--A NEW LOOK AT AN OLD SUBJECT. James H. Martin, Dept. of Biology, J. S. Reynolds Cmnty. Col., Richmond, Va. 23241

The Triassic sediments in the Richmond Basin were visited to locate a collection site for vertebrate fossils. Three sites north of the James River were examined and one (a quarry) has provided large numbers of well preserved fish. Two horizons designated L20 and L75 consist of thinly laminated gray shale which contain carbonized fish remains in quantities of approximately 100 per m<sup>2</sup> and 5 per m<sup>2</sup> per cm of laminate respectively. Ganoin from L75 specimens can be removed from scale surfaces to reveal growth rings; scales can be dissected away to reveal blood vessels and other anatomic features. Methods of penetrating whole fish with epoxy resins are being developed in order to remove and section whole fish for more complete anatomical studies. L20 specimens average 4 cm long and appear to consist of 6 species. L75 specimens, most of which have been identified as *Dictyopyge*, range from fragments to whole fish with body lengths from 9-20 cm. A third horizon (L80) is a black, coarsely laminated, shale having undergone considerable deformation & heating and containing a considerable number of ganoid fish parts and posterior body segments.

Considering the abundance of fossils, the lack of information concerning the vertebrate fossils in the Richmond Basin and the fact that quarrying operations are rapidly destroying the available sources, it is suggested that scientists and students immediately begin to re-examine the Richmond Basin.

COMPARATIVE TOLERANCE OF HEADWATER AND MAINSTREAM FISHES FOR ABRUPT CHANGE IN pH, DISSOLVED OXYGEN, AND TEMPERATURE. W. J. Matthews and J. T. Styron, Jr. Dept. of Biology, Roanoke Col., Salem, Va. 24153.

The tolerance of a headwater cyprinid (*Phoxinus phoxinus*) is compared to that of three mainstream cyprinids (*Notropis ardens*, *Notropis albeolus*, and *Notropis cerasinus*) for abrupt changes in pH, dissolved oxygen, and temperature. *P. phoxinus* was most tolerant of changes in all three factors, supporting the hypothesis that species of intermittent headwaters are harder than those of environmentally stable mainstreams. *P. phoxinus* survived thermal shocks of  $\pm 4$  C, suffered no mortality in oxygen concentrations of 1.0-1.4 ppm, and survived up to 220 min. at a pH of 3.9. *N. cerasinus* was slightly more tolerant of the tested factors than *N. ardens* or *N. albeolus*, and, of those three species, it occurred farthest upstream in a small creek. Even minor differences in environmental tolerance may thus relate to wider distribution of a species.

REPRODUCTION OF *MEGASELIA SCALARIS* (LOEW) (DIPTERA:PHORIDAE) D. G. Martinez\* and R. L. Pienkowski, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

A study was made on the influence of varying parental sex-ratios of *Megaselia scalaris* (Loew) on the number of eggs deposited. Newly emerged, unmated males and females were placed in petri dishes with *Drosophila* growth media covered with black muslin cloth to facilitate counting of eggs. The sex-ratios (female:male) used were 1:1, 1:2, 1:3, 2:1, and 3:1. Treatments were replicated four times. Daily observations were made on the number of eggs laid. The pairs of flies were transferred to new petri dishes as eggs were counted. Parthenogenetic reproduction was not observed. Pre-oviposition period was found to be 1-2 days. Egg laying trend indicated that increasing the number of males decreased the total number of eggs oviposited. The maximum number of eggs was deposited with a 2:1 sex ratio. The different parental sex-ratios did not influence the sex-ratios of emerging offspring. Using a chi-square analysis, the expected ratio of 1:1 was found among emerging-offspring.

COMPARISON OF SMALL MAMMAL OCCURRENCE IN ONE AND FOUR YEAR OLD PINE PLANTATIONS. M. T. Mengak and A. R. Tipton, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State University, Blacksburg, Va. 24061

To determine the distribution of small mammal populations and the potential for damage, a study was conducted in two different aged pine plantations in Lancaster County, South Carolina. Five parallel transect lines were established in both a one and four year old pine plantation. Fifty stations were placed at 10 m intervals with two snap traps at each station. Eight hundred trap nights were recorded on the one year old and 900 trap nights on the four year old. No microtine rodents were caught on either area and no damage to seedlings or trees was found. Fifty four percent of the animals captured on the one year old area were *Reithrodontomys humilis*, with 38% *Peromyscus leucopus* and 8% *Sigmodon hispidus*. On the four year old site, 83% of the animals were *S. hispidus*, 17% were *P. leucopus* and no *R. humilis* were captured. The one year old plantation had much greater diversity of habitat types while the four year old plantation had 75% grass and 25% honeysuckle. Changes in species occurrence was a result of changes in vegetation. The old field-pine ecotone provided suitable habitat for *R. humilis* on the one year old but the absence of this type excluded them from the four year old. *P. leucopus* was found in heavy cover on both areas as expected and *S. hispidus* was found in honeysuckle on both plantations.

MAMMALS OF VIRGINIA: HIGHLIGHTS OF A NEW BOOK. J.F. Merritt. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

A study of the mammals of Virginia was initiated in fall 1976. This research effort is concerned with the collection of data which will ultimately contribute to a monograph on the distribution of mammals in Virginia to be published by the University Press of Virginia. This work concentrates on species accounts, keys, biogeographic patterns and ecological aspects. In addition, history of mammalogy, vegetational patterns and physiography are discussed.

Seventy-four species of native mammals live or recently lived in Virginia. In addition, twenty-six species of marine mammals have been reported to occur along the coast of Virginia. Five species of mammals have been extirpated and two of these restocked. There are three introduced murids, one Histricomorph rodent and one cervid present in Virginia as a result of man's activities. Possibly four Virginia mammals may be classified as endangered pending a decision in the near future. This paper presents an interim report on the proposed design of the monograph focusing on areas mentioned above.

INFLUENCES OF ENERGY INTAKE ON REPRODUCTIVE AND BODY CHARACTERISTICS OF FEMALE *PEROMYSCUS LEUCOPUS*. M. H. Merson and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061

A study was performed examining the relative importance to body composition and reproductive characteristics of dietary energy levels. Thirty-nine female *P. leucopus* were fed for 3 weeks on lab chow ad libitum, 70% ad libitum, or 70% ad libitum supplemented with glucose to give a digestible energy intake comparable to ad libitum. Five mice on the 70% ad libitum diet died. No other mortality was noted. Mice surviving the 70% ad libitum diet lost significantly ( $P < .05$ ) more weight than the other two groups although there was no significant effect on body weight due to diet. The carcasses of the 70% ad libitum mice had significantly greater percentages of ash and water and lower percent fat than the other groups. The total fat in the carcasses of the glucose-fed mice was significantly greater than that in the 70% ad libitum. There was no significant effect of diet on ovarian weights but there was a strong trend for reduction of uterine weights in the glucose-fed and 70% ad libitum groups ( $P < .06$ ). Chi-square analysis showed a significantly lower incidence of estrus in the 70% ad libitum group. There was no difference in the incidence of estrus between the ad libitum and glucose-fed mice. The energy level of the diet *per se* appears to be more important in this species for the maintenance of the estrous cycle than other dietary constituents.



REPRODUCTIVE CHARACTERISTICS OF MOURNING DOVES KILLED DURING THE 1975 AND 1976 HUNTING SEASONS. R. E. Mirarchi\* and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Crops and reproductive organs were collected from mourning doves (*Zenaidura macroura*) at successive weekly intervals (6, 13, 20 September 1975; 11, 18 September 1976) during Virginia dove hunting season. Total number of adult doves examined during successive weeks in 1975 and 1976 were: 132, 49, 9 and 90, 4, respectively. Total numbers of juvenile doves examined during successive weeks in 1975 and 1976 were: 240, 93, 24 and 271, 13, respectively. A reproductive activity score (RAS) was developed based on crop or gonadal data which indicated doves either had dependent young, were potential layers, or were potential breeders. The RAS of mourning doves generally declined progressively during successive weeks of the hunting season. Significant differences in RAS of adults and juveniles occurred between weeks within the same year and between years. The data indicated that some mourning doves are reproductively active during the first weeks of the hunting season and this activity decreases as hunting season progresses. [Supported by the U. S. Fish and Wildlife Service and Va. Comm. Game and Inland Fisheries].

EGG-LAYING CHARACTERISTICS OF A CAPTIVE MOURNING DOVE COLONY. Ralph E. Mirarchi\*, and Patrick F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A captive breeding colony of mourning doves was studied during the breeding season for two consecutive years. Paired birds were held in Quail Battery Breeding Cages (each 48 x 33 x 23 cm) in an unheated enclosed aviary under natural lighting. Feed and water were provided *ad libitum*. The feed consisted of a Quail Layer Ration formulated by the Department of Poultry Science, VPI & SU. Doves were checked daily at 1700 hrs and the number of eggs laid by each pair was recorded. Egg laying began during the last week of February and the first week of April in 1976 and 1977, respectively. Eggs were removed after laying. Egg laying intervals ( $\bar{X} \pm S.E.$ ) between the first and second ( $n=37$ ), and between the second and third clutch ( $n=12$ ) of eggs were  $9.8 \pm 0.6$  days, and  $8.8 \pm 1.1$  days, respectively. No consistent significant differences between egg measurements in each clutch were found within months, although there were significant ( $P<0.05$ ) differences in length of eggs between eggs of each clutch over all months. Significant differences ( $P<0.05$ ) in length of eggs also were found between the first and second egg laid within both the first and second clutches, and over all clutches. Wild mourning doves are adaptable to captive breeding and may prove useful in controlled laboratory experiments. [Supported by the U. S. Fish and Wildlife Service and Va. Comm. of Game and Inland Fisheries].

REGRESSION EQUATIONS USEFUL IN REPRODUCTION STUDIES CONDUCTED ON MOURNING DOVES. R. E. Mirarchi\* and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Crop and gonadal weights were recorded for 209 mourning doves (*Zenaidura macroura*) before (fresh) and after (preserved) a two week fixation period in 10% formalin. Crops of both sexes were segregated into inactive (I), active (A), and developing/regressing (D/R) phases for analysis. Testes weights (TWT), ovary weights (OYW), and oviduct weights (ODW) also were analyzed. Data were analyzed using the stepwise regression procedure of the Statistical Analysis System. The following Maximum R-Square regression equations were developed for crop and gonadal measurements, with preserved (P) and fresh (F) organ weights serving as the dependent and independent variables, respectively:

P A Crop Wt. (g) =  $-0.369 + [1.027 \times F A \text{ Crop Wt. (g)}]$ ;  
P I Crop Wt. (g) =  $0.114 + [0.743 \times F I \text{ Crop Wt. (g)}]$ ;  
P D/R Crop Wt. (g) =  $-0.141 + 0.965 \times F D/R \text{ Crop Wt. (g)}]$ ;  
P TWT (g) =  $-0.004 + [0.987 \times F TWT (g)]$ ; P OYW (g) =  $0.006 + [0.986 \times F OYW (g)]$ ; P ODW (g) =  $-0.001 + [0.934 \times F ODW (g)]$ .  
The  $r^2$  values and error degrees of freedom associated with each equation were: 0.93, 20; 0.79, 138; 0.89, 11; 0.99, 37; 0.99, 86; 0.99, 86 respectively. These equations have proven useful in the standardization of fresh and preserved organ weights prior to statistical analysis. [Supported by the U. S. Fish and Wildlife Service and Va. Comm. Game and Inland Fisheries].

CONTRIBUTIONS TO THE REPRODUCTIVE BIOLOGY OF THE PIRATEPERCH, *APHREDODERUS SAYANUS*. Edward O. Murdy\* and J. W. Edward Wortham, Jr., Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

The purpose of this study was to describe the micro and macro-anatomy of the reproductive system and the testicular and ovarian development in *Aphredoderus sayanus*.

Specimens were collected at least once a month from September, 1976, through May, 1977, in Cypress Pond, a part of the Dismal Swamp drainage, outside of Suffolk, Virginia. Forty-three specimens had their gonads examined histologically, of these 13 were males, 29 were females and in one specimen the sex was not determinable. All specimens were also assessed according to their gonosomatic index (GSI) which was the ratio of the total weight of the gonads to total body weight.

An unknown structure was discovered in the ovaries of two specimens. This structure, which was found in several areas of the ovary, bore no resemblance to any structure that had previously been discussed in the literature.

*Aphredoderus sayanus* is a spring spawner, spent gonads were found on and after April 13, 1977. Gonads began to ripen in the fall, testes maturing sooner than ovaries. Sperm was seen in November males, ripe eggs were not seen until April 1, 1977. No ripe males or females were collected after April 30.

THE TAWNY ALLELE IN *CEPAEA NEMORALIS*. J. Murray and B. Clarke\*. Dept. of Biology, Univ. of Va., Charlottesville, Va. 22901 and Genetics Research Unit, Univ. of Nottingham, England.

In the land snail *Cepaea nemoralis*, the color of the shell is controlled by a locus (C) with a large number of alleles determining different shades of brown, pink, yellow, and white (listed in order of decreasing dominance). Some British populations, especially on sand dunes, contain an unusual color variety that is yellowish-brownish or "tawny". Laboratory crosses demonstrate that this color is determined by a new allele at the C locus ( $C^T$ ). It is dominant to yellow, partially dominant to pink, and recessive to dark brown. The C locus is linked to the principal locus (B) controlling banding of the shell and is unlinked to the M locus that modifies the banding. In shells bearing five bands, tawny is difficult to distinguish from yellow. The factors responsible for the association with habitat are unknown.

THE EFFECT OF PULSED CHLORINE ON THE VENTILATORY ACTIVITY OF RAINBOW TROUT (*SALMO GAIRDNERI*). Dale E. Nichols\* and Cletus M. Sellers, Jr. Dept. of Biology, James Madison Univ., Harrisonburg, VA 22801

Despite voluminous research, chlorine remains the only practical disinfectant for large quantities of water, even though chlorine compounds have been implicated as potential health hazards. Past experimentation on the effects of chlorine on aquatic life has dealt primarily with continuous exposure to chlorine. Even though there is a wide distribution of power plants, which have been in operation for many years, there is little data on the effects of intermittent chlorination to aquatic life. Pulses of chlorine that are passed into receiving waters from power plants are of particular interest to this study, since fish are a major portion of the aquatic life affected by these chlorine pulses.

Using a direct volume determination technique, the effect of a single pulse of chlorine on the ventilatory activity of rainbow trout was investigated. At maximum chlorine concentrations of 0.2 and 0.4 mg l<sup>-1</sup>, ventilatory rate/volume and coughing were all found to increase. No significant difference was found between the fish exposed to 0.2 and 0.4 mg l<sup>-1</sup> chlorine for any of the three parameters studied. A negative correlation was found to exist between ventilatory rate and ventilatory volume.

LEAD CONCENTRATIONS IN FEATHERS OF AMERICAN WOODCOCKS COLLECTED FROM THE UNITED STATES RANGE. Timothy G. O'Brien\*, Patrick F. Scanlon, Neil L. Schauer\*, and Richard G. Oderwald. Depts. Fisheries and Wildlife Sciences, and Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

American woodcocks (Philohela minor) were recovered from hunters in 32 states of the United States Range. Primary feathers from 1008 woodcocks were analyzed for lead by means of atomic absorption spectrophotometry. Data on lead levels were analyzed by state, age of woodcock, and sex of the birds. Significant differences ( $P < 0.05$ ) in lead levels among states were found. No significant differences in lead levels between sexes were found. There were not significant differences in lead levels between young of the year and adult birds. Lead levels in woodcocks were not significantly correlated with 10 human population, highway length, and highway use statistics.

HEAVY METAL LEVELS IN FEATHERS OF WILD TURKEYS FROM VIRGINIA Timothy G. O'Brien\*, Patrick F. Scanlon, Neil L. Schauer\*, David E. Steffen\* and Joe L. Coggin\*. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061, and Va. Comm. Game and Inland Fisheries, Eagle Rock, Va.

Levels of lead, cadmium, nickel, and zinc were determined in primary feathers of 175 wild turkeys (Meleagris gallopavo) which were shot by hunters in 19 counties in 2 physiographic regions (Mountain and Piedmont) of Virginia. Atomic absorption spectrophotometry was used to determine elemental levels. Data were analyzed by county, region, and sex and age of turkeys. Lead and nickel levels did not vary significantly by county, region or by sex and age of the turkeys. Cadmium and zinc varied significantly ( $P < 0.05$ ) by county. Zinc levels were significantly higher in adult turkeys.

ANNUAL VARIATION IN CIRCULATING TESTOSTERONE LEVELS IN COTTONTAIL RABBITS. Anne Oelschlaeger\*, Patrick F. Scanlon, Mary N. Berkaw\*, Roy L. Kirkpatrick, and Francis C. Gwazdauskas. Depts. Fisheries and Wildlife Sciences, and Dairy Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Ninety male cottontail rabbits (Sylvilagus floridanus) were collected by trapping or shooting during the 12 month period December 1972 to November 1973. Attempts were made to obtain 10 rabbits per month and collections were made each month except June. Weights were taken of testes, epididymides, seminal vesicles, and prostates. A blood sample was taken and plasma was analyzed for testosterone by radioimmunoassay. Rabbits were sorted into young of the year and adults based on dried eye-lens weights. Maximum plasma testosterone levels occurred in March ( $1.77 \pm 1.93$  ng/ml) and minimal levels were found in November ( $0.06$  ng/ml). Maximum reproductive organ weights ( $\bar{X} \pm S.E.$ ) were found as follows: Paired testes (April,  $16.47 \pm 2.13$ g); paired epididymides (March,  $4.13 \pm 1.29$ g); seminal vesicles (July,  $0.49 \pm 0.14$ g); and prostate (April,  $0.95 \pm 0.41$ g). [Supported by McIntire-Stennis Act Project 212201-0].

MARINE FOULING COMMUNITY DYNAMICS IN LYNNHAVEN BAY. C. M. Otsuka and D. M. Dauer, Dept. of Biol. Sci., Old Dominion University, Norfolk, Va. 23508

Marine fouling community development was investigated during the period of maximum fouling in Lynnhaven Bay, Virginia Beach, Virginia. Replicated acrylic panels fabricated to conform to specific experimental treatments were used as fouling substrata. Panels of  $1 \text{ cm}^2$ ,  $25 \text{ cm}^2$ , and  $225 \text{ cm}^2$  were employed to evaluate the effects of absolute surface area on community composition. To analyze the effect of increased habitat complexity,  $169 \text{ cm}^2$  panels were augmented with acrylic strips increasing total surface area to  $225 \text{ cm}^2$ . The effect of predation was examined using  $0.56 \text{ cm}$  mesh hardware cloth enclosure cages fitted to  $225 \text{ cm}^2$  panels.

Colonization curves for  $225 \text{ cm}^2$  panels demonstrated that the pattern of species accumulation was greatly influenced by the initial rapid settlement, growth, and subsequent slough-offs of the solitary tunicate Molgula manhattensis. The number of species colonizing panels was directly related to the total surface area available. The predator exclusion treatment developed a very different community composition compared to the control.

AN EVALUATION OF A QUESTIONNAIRE-SURVEY TECHNIQUE ON THE EUROPEAN WILD BOAR POPULATION IN GREAT SMOKY MOUNTAIN NATIONAL PARK. D. K. Otto and A. R. Tipton, Department of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061

The European wild boar (Sus scrofa L.) was introduced to Great Smoky Mountain National Park in the late 1940's or early 1950's. Since 1959 the Park Service has directed a control program on this exotic species, but this had been ineffective. From June 1976 to April 1977 a survey of wild hog sightings in the Park was conducted to collect information on (1) seasonal movements, (2) population size, (3) extensive rooting activity and (4) the current range of wild hogs in the Park. A total of 2300 backpacker questionnaires were given to distribution points within the Park. One hundred forty four or 6% were completed and returned. Low return rates in certain areas of the Park was due to poor coordination and cooperation of Park personnel. Backpackers more frequently reported actual sightings of European wild boar but many reported recent hog activity or even the lack of hogs. Data from Cataloochee subdistrict agrees with other research in designating this as the one major area in the Park where the hogs have not become established. Information pertaining to extensive hog use in particular areas was used to direct control efforts. When conducted on an efficient basis throughout the Park, a survey of this type has the potential to keep management personnel informed of major hog population trends, range, expansion, and high priority control areas.

A COMMENSALISTIC ASSOCIATION BETWEEN CHIRONOMID LARVAE (DIPTERA: CHIRONOMIDAE) AND HYDROPSYCHID PUPAE (TRICHOPTERA: HYDROPSYCHIDAE). C. R. Parker\*, and J. R. Voshell, Jr. Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

During a study of the North Anna River below Lake Anna, Louisa County, VA, larvae of Eukieferiella sp. (Chironomidae) were found inside the closed pupal cases of Hydropsyche spp. (Hydropsychidae). Examination of more than 200 pupal cases revealed that 15% of the cases contained chironomid larvae. Chironomid pupae were also discovered in 2 of the cases. Larvae of Eukieferiella sp. were present in cases containing prepupae, pupae, and pharate adults of Hydropsyche spp. A significantly greater number were found in cases containing pharate adults. There was no indication that the chironomids had been feeding on the hydropsychids or had interfered with their development. This situation probably represents a facultative commensal relationship. The Eukieferiella sp. larvae probably enter the pupal case after closure. At this stage in their development the hydropsychids are no longer feeding, and the chironomid larvae thus gain a safe refuge for their own development. A brief review of other chironomid-aquatic insect associations is also included.



CAPACITY FOR INCREASE OF *MEGASELIA SCALARIS* (LOEW) (DIPTERA: PHORIDAE), RESEARCH AS A GRADUATE-LEVEL CLASS EXERCISE. R. L. Pienkowski, J. T. Trumble, D. G. Martinez\*, J. M. Ferguson\*, J. G. Fairservice\*, and P. F. Dowd\*. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061.

The capacity for increase ( $r_c$ ) is a statistic designed to give an estimate of the rate of reproduction for a given species under a given set of conditions. It incorporates mortality rate, developmental rate, fecundity, and sex ratio. It can be used as an approximation for  $r$ , instantaneous rate of population increase, or  $r_m$ , the innate capacity for population increase. The capacity for increase will be determined for *M. scalaris* under both favorable and unfavorable conditions.

This research was conducted by students as a part of a graduate level course in insect ecology. I recommend caution in using this approach to a laboratory course. The students must be capable of conceiving both the problem and the methods for solving it. The exposure of the student to practical ecology is narrower in scope, but more intense. By assigning a variety of types of research problems, student interaction tends to broaden their experience and to facilitate problem solving. The insect to be used must have a short life-cycle and must be easily reared.

A STUDY OF STRANGE MALE INFLUENCE ON POSTIMPLANTATION GROWTH OF PRAIRIE DEERMOUSE FETUSES. Laura C. Pinkston and C. R. Terman. Lab. Endocrinology and Population Ecology, Biology Department, College of William and Mary.

Effect of exposure to a strange male in post-implantation pregnancy was examined in the following situations: exposure to a strange male for five days of an inseminated female beginning shortly after implantation (Day 6 postinsemination), mid-way through gestation (Day 12 postinsemination), and shortly before parturition (Day 17 postinsemination). It was found that weights of the experimentals were significantly lower than the controls in some treatments when considering grvida with 1-5 fetuses. No significance was found in grvida of larger sizes for any treatment. Within each treatment, a trend was found where the controls had larger fetal weights for grvida of smaller sizes and experimentals had smaller fetal weights for grvida of smaller sizes. It seems that there is something operating to protect the fetuses in larger grvida from the influence of the strange male. It was also found that there was a decrease in number of pregnancies of inseminated females treated on Day 6 postinsemination, although not significant.

HUMAN UNDERWATER VISION. L. A. Rivamonte\*. Science Dept., Maury High Sch., Norfolk, Va. 23517

Human underwater vision is strongly hypermetropic (farsighted) due to the loss of the refractive power of the cornea in water. Paradoxically the results of an underwater visual acuity study and the observations of other researchers indicate that acuity improves dramatically with decreasing viewing distance. At one meter the minimum angular resolution (MAR) between the black and white bars of a grating was 17.5 minutes while at distances greater than two meters the MAR was greater than 2.0 degrees. This decrease in resolution with distance can be explained in terms of ray selection and channeling by the photoreceptors acting as waveguides. The paradoxical increase in hypermetropia with respect to decreasing animal size can also be explained in terms of the waveguide properties of the photoreceptors.

TAXONOMY AND KNOWN BIOLOGY OF *MEGASELIA SCALARIS* (LOEW) (DIPTERA:PHORIDAE). William H Robinson\*. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The dipterous family Phoridae includes over 200 genera and 2400 species worldwide. The general morphology of the adult and immature stages place this family in a unique position in the Diptera suborder Cyclorhapha. *Megaselia scalaris* is one of the most unusual phorids; the adult egg-laying habits and the larval feeding habits have brought this species to the attention of many biologists.

The adults have been collected from flowers, homes, sewage treatment plants, and caves. The larval stages have been reported feeding on living and dead plants and animals. *M. scalaris* is distributed worldwide.

Although the larvae have been reported as parasites and predators, the structure of the mouthparts indicates it functions in saprophagous feeding.

IMPACT OF NON-POINT POLLUTION ON BENTHIC INVERTEBRATES IN THE LYNNHAVEN RIVER SYSTEM. I. INTRODUCTION. W. W. Robinson, D. M. Dauer, C. P. Seymour, and A. T. Leggett, Jr., Dept. Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508

A study was conducted in the Western and Eastern Branches of the Lynnhaven River complex in order to assess the biological effects of non-point pollutants upon estuarine macroinvertebrates. Due to increased urbanization in the area of the Lynnhaven, non-point sources of pollution increase the nutrient content of the adjacent waters with possible enrichment effects. In this study two types of data were collected. Individual oysters placed in retrievable cages in the Lynnhaven were monitored for growth. In addition, 10 permanent sampling sites were located in the intertidal zone of the Lynnhaven from the inlet at the mouth to the headwaters of both branches. Various biological parameters were studied at each site (e.g., species numbers, community density, community biomass) by collecting bimonthly samples from August 1976 through June 1977. Benthic invertebrate samples were similarly collected from Old Plantation Creek on the Eastern Shore for comparison with the Lynnhaven samples.

$\text{Na}^+\text{K}^+$ -ATPASE IN THE GILL-MANTLE COMPLEX OF THE EURYHALINE CLAM *RANGIA CUNEATA*. David G. Sainsing\* and David W. Towle. Dept. of Biology, Univ. of Richmond, Richmond, Va. 23173.

The brackish water clam *Rangia cuneata* has been shown in other laboratories to maintain body fluid osmolarity above that of the medium in salinities below 10 o/oo. It is not known which tissues are responsible for osmoregulation in this organism. Since the membrane-bound enzyme  $\text{Na}^+\text{K}^+$ -dependent ATPase has been implicated in osmoregulatory processes in many aquatic organisms, we measured the levels of  $\text{Na}^+\text{K}^+$ -ATPase activity in homogenized tissue samples from mantle, gill, rectum, ventricle, kidney, and foot (including epithelial and muscle tissue). Mantle, gill, and kidney showed substantial enzymatic activity while rectum, ventricle, and foot showed virtually none. Ouabain-binding determinations on parallel samples also indicated that the greatest number of enzyme molecules (ouabain binding sites) were in mantle, gill, and kidney. Turnover numbers, calculated for each tissue, indicated that the mantle pump sites had the highest catalytic activity. Gill and kidney turnover numbers were approximately one-half that of mantle. The hypothesis that the kidney takes part in active absorption of ions from the medium may be discounted on an anatomical basis. The data suggest that the gill-mantle complex is the primary site of ionic regulation associated with osmotic adaptation in *Rangia*, with the mantle providing the major share of pumping activity.

PLASMA GLUCOSE AND PLASMA CORTICOID LEVELS IN MICE SUBJECTED TO VARIOUS DURATIONS OF ANESTHESIA WITH METHOXYFLURANE. Patrick F. Scanlon, James A. Wesson\*, Wanda B. Morehead\* and Francis C. Gwazdauskas. Depts. Fisheries and Wildlife Sciences and Dairy Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

One hundred adult male white mice (*Mus musculus*) were divided into 5 treatment groups of 20 animals each. One group served as a control. The other 4 groups were subjected to methoxyflurane (Metafane, Pittman-Moore) for periods of 15, 30, 60, or 120 minutes. At the end of exposure mice were killed by decapitation and blood collected. Control mice were subjected to similar handling. Blood plasma was analyzed for corticoids by a competitive protein binding assay. Plasma glucose was measured with a Gluco Strate Kit (General Diagnostics). Mean ( $\pm$  S.E.) levels of plasma glucose (mg %) for control, 15, 30, 60, and 120 minute groups were  $138.6 \pm 5.8$ ,  $225.9 \pm 19.6$ ,  $141.9 \pm 9.4$ ,  $151.6 \pm 11.8$ , and  $150.9 \pm 7.5$ , respectively. Plasma glucose increased significantly ( $P < 0.05$ ) at the 15 minute sampling. Plasma glucose levels at the 30, 60, and 120 minute samplings were not significantly different from control animals. Mean ( $\pm$  S.E.) corticoid levels (ng/ml) for control, 15, 30, 60, and 120 minute groups were:  $39.23 (\pm 6.55)$ ,  $89.76 (\pm 7.21)$ ,  $118.92 (\pm 9.20)$ ,  $96.09 (\pm 9.22)$ , and  $104.79 (\pm 8.58)$ , respectively. Corticoid levels were significantly ( $P < 0.05$ ) higher than controls in all treatment groups.

THE EFFECT OF DIETARY SUCROSE ON THE RATE AT WHICH RAT JEJUNUM WILL HYDROLYZE SUCROSE AND ABSORB GLUCOSE. S. L. Snyder-Schurtz\*, and M. A. Gordon. Dept. of Biology, James Madison Univ., Harrisonburg, VA 22801

To test a hypothesis that dietary sucrose would enhance sucrose hydrolysis and uptake of glucose in rat jejunum, six experimental animals were maintained on a standard diet with 0.8 M sucrose as their water supply. Experimental design was modified from Crane, *Biochim et Biophys Acta* 45, 460-476.

The jejunal tissue hydrolyzed sucrose and absorbed the constituent monosaccharide, glucose, at rates of  $8.33 \times 10^{-3}$  and  $0.256 \times 10^{-3}$  mg glucose . mg protein $^{-1}$  . sec $^{-1}$  for the experimental and control animals, respectively. This difference was significant to a probability value of 0.01.

It can thereby be concluded from these results that an increased rate of glucose from sucrose can be induced by dietary sucrose.

AVIAN PREDATION AT UNITED STATES FISH HATCHERIES. Ralph E. Stultz\*, Patrick F. Scanlon, and Louis A. Helfrich. Dept. Fisheries and Wildlife Sci., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A survey of federal fish hatcheries in the continental United States and Alaska was conducted to determine the extent and severity of avian predation on fish hatcheries as well as to determine what avian species were the most serious predators. A list of 58 birds species in 14 families was provided. Managers of hatcheries were asked to indicate which species or members of what family caused problems by predation in their hatcheries. They were asked to rank the severity of the problem i.e. severe, significant, trivial, or none. They were also asked which fish species were preyed upon and also to identify any bird predators not on the list provided. The survey elicited a 70 percent response from 121 managers. Of the 58 species on the survey form 28 species in 9 families were mentioned by managers as predators visiting fish hatcheries. Additionally, 7 species from 5 other families were added by managers as being pests at hatcheries. Seventeen species in 9 families were mentioned as causing "severe" damage to fish stocks.

SEASONAL FOOD HABITS OF COTTONTAIL RABBITS IN TWO AREAS OF VIRGINIA. D. J. Shoemaker\*, R. L. Kirkpatrick, and B. S. McInnes\*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The seasonal food habits of cottontail rabbits (*Sylvilagus floridanus*) from two areas of Virginia, the Mountain and Piedmont regions, were determined using an histological microtechnique. Fragments were identified to genera and species when possible. These fragments plus fragments unidentified to genera or species were classified as to forb, grass, seedcoat, bud, or bark. Relative surface area of fragments in the stomachs was used to quantify percent composition. Only 3 species (*Festuca* spp., *Poa* spp., and *Agrostis* spp.) were found in both regions for all four seasons. Forbs comprised a greater percent than grasses in the summer and fall of the Piedmont diets. Grasses formed a greater percent of the Mountain rabbit diets than forbs year round. *Poa* spp. comprised the greatest percent of the identified fragments in the winter and spring for both areas. *Festuca* spp. was second most abundant in both areas in the spring and winter in the Piedmont region, and third in the winter Mountain sample. *Dactylis glomerata* was in the top 5 most abundant species in both areas in the spring and summer as was *Lespedeza* spp. in the summer and fall Piedmont diets. *Ambrosia artemisiifolia*, *Echinochloa* spp., *Phleum pratense*, *Plantago* spp., and *Solidago* spp. were the next most abundant species overall.

NICKEL EFFECTS ON CELL DIVISION, CALCIFICATION AND CELL PROTEIN IN THE COCCOLITHOPHORID, CRICOSPHERA CARTERAE. E. F. Stillwell and J. R. Holland\* Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Cell division, calcification, and cell protein in the coccolithophorid algae *Cricosphaera carterae* were affected in the presence of nickel (Ni). As the concentration of Ni in the medium was increased from 0-5  $\mu$ M Ni the rate of cell division increased slightly. At higher Ni concentrations the rate of cell division decreased progressively with almost complete blockage at 400  $\mu$ M Ni. Calcification of cells was retarded at concentrations of Ni greater than 50  $\mu$ M. The inhibition of cell division and calcification was reversible after the transfer of cells to control medium. After three days of experimental treatment, cell protein was slightly greater than controls at 5-50  $\mu$ M Ni, and decreased at concentrations of 75  $\mu$ M Ni or higher. After four days of experimental treatment, cell protein was approximately the same for all Ni concentrations except for a marked decrease in 400  $\mu$ M Ni.

SOCIAL CUES INFLUENCING RECOVERY OF REPRODUCTIVE ORGANS IN INHIBITED PRAIRIE DEERMICE IN LABORATORY POPULATIONS. C. Richard Terman, Department of Biology, College of William and Mary.

Populations were founded by releasing four males and four pregnant females into enclosures containing 20 sq. ft. of floor area, nest boxes, food and water in surplus. Offspring between 130-150 days of age were paired with sibs of the opposite sex and placed in "No-Contact" cages either (1) within the population enclosure where they received visual, auditory and olfactory stimuli from the populations; or (2) outside of the population enclosure but in the same room. Other sibs were (3) left freely ranging in the population. Treatment continued for 100 days.

The data indicate that animals removed from tactile communication with the population developed significantly larger reproductive organs than their freely ranging sibs. However, the development of the reproductive organs was significantly less among those animals caged within the population than those caged outside. Thus, within the populations, once such inhibition has occurred, other cues (auditory, visual, olfactory) may act to retard reproductive recovery.



ALPHA-GLYCEROPHOSPHATE DEHYDROGENASE OF THE BLUE CRAB *CALLINECTES SAPIDUS*. James F. Todd\* and James E. Dendinger. Dept. of Biology, James Madison Univ., Harrisonburg, Va. 22801

One of the well known changes of decapod crustacean metabolism during the molt cycle is the increase of the lipid component of various tissues prior to molt. L-alpha-glycerophosphate is necessary for the formation of mono-, di-, and triglycerides, and can be formed from dihydroxyacetone phosphate by the enzyme alpha-glycerophosphate dehydrogenase (CPDH) (E.C. 1.1.1.8). This enzyme has been reported to exist in multiple molecular forms (isoenzymes) in tissues of various vertebrates and the bumblebee. Little has been reported about the molecular nature of this enzyme in crustaceans.

We have determined the optimal conditions for electrophoretic separation of blue crab cytoplasmic NAD-linked GPDH in polyacrylamide gel and visualization by nitroblue tetrazolium. This enzyme occurs in multiple molecular forms in *Callinectes sapidus*.

Electrophoresis was carried out at a constant current of 2 mA/column for 150 min at pH 8.3 in Tris-glycine buffer with 1 mM 2-mercaptoethanol at 10° C. For visualization, gels were incubated one hour at 20° C in staining mixture containing 0.8 mM NAD, 0.018 mM phenazine methosulfate, 0.24 mM nitroblue tetrazolium, 2 mM L-alpha-glycerophosphate, 140 mM KCl, and 0.4 M Tris-HCl buffer at pH 8.6.

VERTICAL DISTRIBUTION OF PROTOZOANS IN AN APPALACHIAN SOFT-WATER POND. Michael R. Van Brunt and William H. Yongue, Jr. Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Covering a little over 37,300 m<sup>2</sup> Pandapas Pond is located in Montgomery County, Virginia. Characteristically it is a soft-water pond with pH usually just below neutral. Previous studies to summer 1976 show Pandapas possesses an atypical phytoplankton community that is suggestive of an allochthonous based system. Earlier studies done during other seasons show the pond to have a stable protozoan community.

During the months of July and August, 1976 a investigation was conducted on the plankton protozoan populations of Pandapas Pond for one location in the pond. Four depths were sampled at approximately weekly intervals. Sampling was accomplished by pumping pond water to the surface and concentrating it through a 10 micron mesh plankton net. In the lab. samples were examined for the kinds of protozoa present and their abundances.

Flagellates were abundant and predominant of the protozoa. In terms of numbers *Trachelomonas hispida* was found the dominant species. Moreover, the data showed a definite stratification of population densities, which is a possibility unaccounted for in many pond investigations.

DEVELOPMENT AND SURVIVAL OF *MEGASELIA SCALARIS* (LOEW) (DIPTERA:PHORIDAE) AT SELECTED TEMPERATURES AND PHOTOPERIODS. J. T. Trumble and R. L. Pienkowski, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

*Megaselia salaris*, obtained from laboratory stock, were reared on commercial *Drosophila* media. Newly eclosed first instars were placed on freshly prepared diets and observed for developmental time and survival to the adult stage at selected photoperiods and temperatures. The insects were examined every 12 h; newly formed puparia were removed and labeled individually. With few exceptions, the developmental time and rate of survival decreased with increasing temperature. Mean developmental time of insects reared at 21.1°C showed an increase of approximately 300% over those reared at 32.2°C. Percent survival fluctuated from a low of 50.0 at 32.2°C to a high of 82.0 at 21.1°C. In general, a photoperiod of LD:12-12 permitted more uniform survival for each temperature than LD:16-8. Photoperiod had little effect on development from first instars to puparia, but did effect rate of development thereafter.

EVALUATING NUTRITIONAL STATUS IN COTTONTAIL RABBITS USING PHYSIOLOGICAL CHARACTERISTICS. R. J. Warren\* and R. L. Kirkpatrick, Dept. of Fisheries & Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Four male and 4 female cottontail rabbits (*Sylvilagus floridanus*) were fed ad libitum or 25% restricted diets for 2 weeks in a 2x2 factorial experiment. Restricted rabbits lost more weight than ad libitum rabbits (P<0.07). Restricted rabbits had significantly (P<0.001) less perirenal fat, as expressed by the kidney fat index (KFI), than ad libitum rabbits. The KFI averaged 36.2 ± 2.3 (SE) % for ad libitum rabbits compared to 12.6 ± 4.8 % for restricted rabbits. A significant (P<0.04) interaction between nutrition and sex was observed in the analysis for this characteristic, however. Femur marrow fat was not significantly different between ad libitum and restricted rabbits. Levels of serum cholesterol were significantly (P<0.05) greater for restricted rabbits than for ad libitum rabbits, averaging 98.1 ± 3.9 mg/dl and 75.3 ± 6.9 mg/dl, respectively. No nutritional effects were observed on albumin or urea nitrogen in serum. Female rabbits tended to have higher levels of serum albumin than males (P<0.07). Levels of urinary urea nitrogen expressed as a ratio to urinary creatinine were unaffected by nutritional restriction.

SERUM PROGESTINS DURING GESTATION IN THE COTTONTAIL RABBIT. R. J. Warren\*, R. L. Kirkpatrick, and F. C. Cwazdauskas. Depts. of Fisheries & Wildlife Sciences and Dairy Science, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Fifty-six female cottontail rabbits (*Sylvilagus floridanus*) were collected between the months of April and June. Gestational stage was estimated based on uterine characteristics and fetal development. Blood serum obtained following cardiac puncture was assayed by competitive protein binding procedures to estimate progesterin levels. Paired ovarian weights tended to increase as gestation progressed. The mean ovarian weights observed ranged from a low of 84.4 ± 6.5 (SE) mg in nonpregnant/postpartum (NP/PP) rabbits to a high of 147.1 ± 6.5 mg for rabbits in Week 3 of gestation (P<0.05). Progesterins fluctuated throughout gestation, probably the result of individual variation. Average progesterin levels observed for the 4 weeks of gestation, respectively, were: 3.36 ± 0.85 ng/ml, 2.14 ± 0.35 ng/ml, 3.81 ± 0.50 ng/ml, and 1.56 ± 0.43 ng/ml, compared to 3.45 ± 0.35 ng/ml for NP/PP rabbits. The levels observed for Weeks 3 and 4 were significantly different (P<0.05). Even when expressed as progesterin/fetus, the fluctuating trend was still evident. These data suggest that levels of progesterins decrease during the last week of gestation, probably because of ensuing parturition.

THE EFFECTS OF MIXED AFLATOXIN AND COPPER ACETATE DIETS ON TRYPTOPHAN METABOLISM IN THE MALE HOLTZMAN RAT. L. B. Weekley\*, T. D. Kimbrough, R. W. Weaver\*, and G. C. Llewellyn. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284

Thirty-three male Holtzman rats were fed either a mixed aflatoxin (AFT) or mixed AFT plus copper acetate (CuAc) diet for a period of 150 days. At sacrifice, serotonin, norepinephrine (NE), dopamine, and 5-hydroxy-indoleacetic acid were measured in pineal, pituitary, the various brain regions and in duodenum. Slight reduction in pineal, pituitary, and whole brain 5HT were observed in both the AFT and AFT+CuAc diet groups, while the NE/5HT ratio remained essentially constant between the groups. Urinary levels of kynurenin and kynurenic acid were also measured. Alterations in distribution patterns of tryptophan metabolites is considered with respect to variations in enzyme activity of both tryptophan pathways.

INDUSTRIAL MELANISM IN MOTHS OF THE CENTRAL APPALACHIANS. D. A. West. Dept. of Biology, VPI & SU, Blacksburg, Va. 24061.

Industrial melanic forms of the geometrid moths *Biston betularia cognataria*, *Ectropis crepuscularia*, *Epimecis hortaria*, and *Iridopsis larvaria* are found at overall low frequencies in the central Appalachians. Population samples suggest that local pollution sources are responsible for higher frequencies of melanics in areas close to those sources, but that there are subtle and widespread effects of air pollution throughout the region, even in apparently unspoiled woodland at high elevations, and that these have affected the fitnesses of typical and melanic phenotypes despite the lack of obvious environmental change. The widespread pollutants apparently come from industrial areas on the east coast and in the Ohio and Tennessee Valleys.

POSSIBLE IMPLICATION OF TOXAPHENE AS A CAUSATIVE AGENT FOR LARVAL FISH ABNORMALITIES IN A SOUTH-CENTRAL RESERVOIR. J. H. Wilson and M. T. Masnik, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555

Larval fish collected during the summers of 1975, 1976 and 1977 from Dardanelle Reservoir on the Arkansas River in Arkansas have exhibited three distinct kinds of abnormalities. As many as 50% of the collections from some areas of the reservoir have contained specimens of larval fish from six different families which exhibit one or more of the abnormalities recorded. Evidence will be presented indicating that toxaphene, a chlorinated hydrocarbon used to control agricultural pests on cotton and soybeans, may be responsible. The incidence of abnormalities among populations of larval fish in the reservoir seems to be declining, probably as a result of reduced usage of toxaphene in the watershed.

AGONISTIC BEHAVIOR BETWEEN BROOK AND RAINBOW TROUT IN AN ARTIFICIAL STREAM ENVIRONMENT. J. R. Wolfe, Jr.\*, L. A. Helfrich\*, and A. R. Tipton\*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The impact of introduced rainbow trout on populations of native brook trout in the southeast United States is not well known. The subject of this study is the agonistic behavior expressed by both species. Wild adult trout were observed in an artificial stream environment. Twenty pairs of fishes were observed with both intraspecific and interspecific matches. Observations of dominance, activity, nipping, and feeding success were quantified and interpreted with respect to species, size, and sex. Dominance was determined by supplanting. Brook trout were dominant in nine of fourteen interspecific matches. Results of activity, nipping, and feeding success demonstrated differences between species, with rainbow trout displaying greater aggressiveness. Qualitative differences in agonistic behavior were found between species. Interspecific communication was adequate for dominance to be established in all pairs. In spite of the differences stated, brook trout were found to compete successfully with rainbow trout in a behavioral context.

MICROSCOPICAL AND BIOCHEMICAL ANALYSES OF HUMAN SEMEN ASSOCIATED WITH FERTILITY PROBLEMS. J.W. Edward Wortham, Jr., Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508, Bart Picone\* and James H. Yuan, Dept. of Chemical Sciences, Old Dominion University, Norfolk, Va. 23508, and Anibal A. Acosta, Dept. of Obstetrics and Gynecology, Eastern Virginia Medical School, Norfolk, Va. 23501

Microscopical and biochemical analyses were performed on 24 semen samples representing 18 individuals. Sixteen of these individuals were from couples having difficulties with conception while two of the samples were from individuals of proven fertility. Semen samples from five of the individuals were examined at least twice.

Microscopical examination included a sperm count utilizing a hemocytometer (two different dilutions were routinely used), a careful evaluation of sperm morphology (at least 200 cells were classified) and an assessment of sperm motility. In addition, liquefaction, color and volume of the specimen was noted.

Biochemical determination of five enzymes was performed on the seminal plasma of the 24 specimens. The enzymes studied were Alkaline Phosphatase, Acid Phosphatase, NADase, 5'-Nucleotidase and Nucleotide Pyrophosphatase.

There were no clear cut relationships between the enzymes studied and the microscopical data. Therefore, the quantity of these enzymes may be of little diagnostic value. However, an examination of their isozymes may need to be done before their true diagnostic value is known.

THERMOPHILIC AMOEBAE FROM SOME EASTERN VIRGINIA LAKES AND PONDS. W. H. Yongue, Jr. Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Samples of plankton, mud, and material from polyurethane foam substrates collected from 11 eastern Virginia lake and pond sites were cultured at 44C ± 1 by adding rice to samples and by plating from this on to cornmeal-agar. Thermophilic amoebae of the genera *Naegleria* and *Acanthamoeba* have been isolated from all samples but not from all replicates. Attempts to maintain isolates for long periods have been unsuccessful due to a phycomycete contaminant. Consistently it appears in the third or fourth transfer. The growth of soil-freshwater amoeba at 44C suggests a possible relationship to *Naegleria fowleri*, a cause of primary amebic meningoencephalitis, which grows well at that temperature. Earlier reports have suggested that 44C is a selective temperature for the pathogenic amoeba. Although numerous protozoans are associated with the samples before culturing, only amoebae grew at that high temperature in these studies. There is no evidence that the temperature is selective for any one species for several morphological types seem to grow equally as well.



## Section of Botany

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

FOREST ENCROACHMENT OF A MARSH IN THE GREAT DISMAL SWAMP, NORTH CAROLINA. L. Scott Andrews, U.S. Geological Survey, Office of Remote Sensing, Reston, Va. 22092

A portion of the Great Dismal Swamp, in North Carolina, was examined for vegetation change occurring over the past fifty years. This change was marked by the encroachment of trees species, primarily *Acer rubrum*, into a once open marsh environment. Analysis methods included aerial photographic interpretation, and examination of increment borings from trees in the area. Interpretation of historical aerial photographs has indicated that invading tree species have claimed 93% of the marsh area since 1937. Examination of increment borings has revealed that the major extent of this invasion has occurred within the past thirty years. The recent change in vegetation type appears to have been associated with the reconstruction of old drainage canals in the 1940's.

BRYOPHYTES ON HEMLOCK BLUFFS OF THE PIEDMONT AND COASTAL PLAIN OF VIRGINIA. D. A. Breil, Dept. of Natural Sciences, Longwood Col., Farmville, Va. 23901

Canadian hemlock (*Tsuga canadensis*) is a common tree of moist ravines in the Blue Ridge and Appalachian Mountains. In the piedmont of south-central Virginia, Canadian hemlock trees occur only in relict stands on north-facing bluffs over rivers. These cool, moist, sandstone bluffs might be expected to harbor bryophytes with affinities to those of mountainous areas. In this study, four hemlock bluffs were examined. Forty-five species of mosses and 22 species of hepatics were collected from diverse microhabitats. There is little evidence of species overlap in the bryophyte flora between communities. Common species include *Thuidium delicatulum*, *Dicranum scoparium*, *Hypnum imponens*, *Bartramia pomiformis*, *Platygyrium repens*, *Bazzania trilobata* and *Odontoschisma prostratum*, all "weedy" species. With the possible exception of *Bazzania trilobata*, none of these species can be considered as relict or related only to bryophytes of colder mountainous areas. These synusial communities are probably too small to maintain an environment favoring a relict bryophyte flora.

TREE DIAMETER GROWTH IN FOUR PLANT COMMUNITIES IN THE GREAT DISMAL SWAMP. Frank P. Day, Jr. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

The radial growth of prominent tree species was measured by aluminum vernier tree bands in four plant communities in the Dismal Swamp (mixed hardwood, red maple-gum, bald cypress, and Atlantic white cedar). Growth rates were variable but peaks occurred in May, June, and July of 1977. The mean annual growth rate for all trees measured in each community was greatest in the most extensively flooded community (cypress) and least in the most infrequently flooded community (mixed hardwood). Radial growth was apparently greatest on the wettest sites, at least for those species normally associated with swamps. Two oak species exhibited slower growth rates than oaks located in a Southern Appalachian mesic forest. The summer of 1977 was extremely dry so measurements during additional growing seasons are required to fully evaluate tree growth in the Dismal Swamp.

PHYTOPLANKTON RANGE MAPS FOR THE EASTERN COAST OF THE U. S. H. G. Marshall, Dept. Biology, Old Dominion University, Norfolk, Va. 23508.

Using a data base of phytoplankton observations taken from 23 cruises in waters between Nova Scotia and Florida, a series of species distribution maps are presented. Seasonal variations in species distribution are given for 24 major forms in this area. Emphasis is placed on the phytoplankton in the shelf waters with some collections and ranges extending several hundred miles seaward. Representative diatoms, pyrrhophyceans, coccolithophores, and silico-flagellates are given with emphasis to species associated with general distribution patterns north and south of Cape Hatteras, N.C. Phytoplankton having extensive ranges along the coast include *Rhizosolenia alata*, *R. calcar avis*, *Melosira sulcata*, *Thalassionema nitzschioides*, *Coccolithus huxleyi*, *Cyclcoccolithus leptoporus*, *Ceratium furca*, *C. tripos*, among others. A distinct difference in species composition is noted in the Cape Hatteras area. This is more evident with the subtropical species characteristic to the Gulf Stream with a greater entry of boreal and temperate types found south of Cape Hatteras near shore than in waters seaward. Examples of patchiness are given for development of blue green populations over the southeastern shelf waters, with near shore blooms of *Rhizosolenia* and *Synedra* species noted.

NOTES ON HIGHER FUNGI FROM VIRGINIA. O. K. Miller, Jr., Biology Dept., VPI & SU, Blacksburg, Va. 24061.

Sixteen interesting species of Homobasidiomycetes, Agaricales including eight species in the Tricholomataceae are reported from Virginia including: *Armillaria caligata* (Viviani) Gill., *Catathelasma ventricosa* (Pk.) Sing., *Collybia spongiosa* (Berk. & Curt.) Sing., *Macrocystidia cucumis* (Pers. ex Fr.) Heim, *Tricholoma aurantium* (Schaeff. ex Fr.) Ricken, *T. decorosum* Peck, *T. sulphureum* (Bull. ex Fr.) Kummer, and *T. terreum* (Schaeff. ex Fr.) Kummer. Six species of *Amanita* in the Amanitaceae including: *A. cokeri* (Gil. & Kuhn.) Gilbert, *A. cothurnata* Atk., *A. parvivolva* (Pk.) Gilbert, *A. porphyria* (Alb. & Schw. ex Fr.) Secr., *A. ravenellii* (Berk. & Curt.) Sacc., and *A. roanokensis* Coker occur in Virginia. In addition, *Volvariella hypopitys* Fr. in the Pluteaceae and *Rhodocybe mundula* (Lasch) Sing. in the Entolomataceae are discussed. The ecology and the relationships of these taxa to other fungi are discussed.

WINTER INJURY OF RHODODENDRONS. G. M. Shear, Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061

Rhododendron hybrids have been developed to extend the range of flower, leaf and plant forms, many by crossing spp. from different climates, thus producing plants of variable hardiness. Hardiness ratings are based on the experience of growers and are influenced by plant vigor, exposure and available water. The winters of 1976-77 and 1977-78 were colder than normal and various degrees of injury from plant kill, to flower bud kill, to various amounts of leaf scorch were experienced at Blacksburg, VA. A minimum temperature of -15F was reached in 1976-77 which contributed to the death of 7 varieties ranging in hardiness ratings from -5 to -15F, flower bud kill on 6 with hardiness ratings of -5 to -15F, severe dieback on 3 with hardiness ratings of -5 to -15F and leaf scorch on 6 with hardiness ratings of -5 to -25F out of 150 varieties. During the winter of 1977-78 a minimum of -8F was recorded. One variety with a hardiness rating of -5F was killed. Some flower bud injury occurred, however, severe leaf scorch was prevalent on a wide range of varieties with hardiness ratings from 0 to -25F. This resulted in partial to complete defoliation. A partial snow cover during the extended cold period protected covered foliage and stems from killing or leaf scorch. One newly planted variety was girdled just above the soil level indicating incomplete dormancy. A light freeze in early May, 1978 caused damage to tender growth.

THE VASCULAR FLORA OF DRAGON SWAMP, MIDDLESEX COUNTY, VIRGINIA. Elizabeth L. Train. Dept. of Biology, The College of William and Mary, Williamsburg, Va. 23185.

Dragon Swamp bisects the Middle Peninsula of Virginia and forms the boundary between Gloucester and Middlesex Counties. The study area encompasses approximately 24 square miles. Collection of vascular plants began in April 1977 and continued through April 1978. 532 species representing 111 families have been identified.

Major plant communities present include freshwater marshes, swamp bottoms, shallow ravines, deciduous woods, pine stands, mixed pine-deciduous woods and recently disturbed areas. Each of these habitats yielded characteristic species. Plants of particular interest include *Lycopodium lucidulum*, *L. appressum* and *Ophioglossum vulgatum*.

THE EFFECTS OF LOW TEMPERATURE AND INDUCED WATER STRESS ON THE RESPIRATION OF SELECTED ARCTIC AND TEMPERATE MYCORRHIZAL FUNGI. R. K. Antibus, A. E. Linkins, and O. K. Miller. Dept. of Biology, V.P.I. & S.U., Blacksburg, Va. 24061.

The impact of temperature and water stress on the respiration of isolates of *Cenococcum graniforme* from a temperate ecosystem, and from tundra at Cape Simpson, Alaska, and *Entoloma* sp. isolated from Barrow, Alaska has been investigated. The effect of temperature on the rate of oxygen uptake by pure cultures of these fungi over a range from 1 to 30°C has been measured by standard manometric techniques. The respiratory responses of these fungi to varying degrees of water stress were followed by the addition of PEG 4000 in various concentrations to the respiration flasks.

Arrhenius linear transformations of temperature dependent data for the isolates grown at 20°C show characteristic breaks at various temperatures. These results suggest a loss in cold tolerance has occurred in Arctic isolates, since ectomycorrhizal roots studied at Barrow, Alaska demonstrated no distinct break in an Arrhenius plot from 0.5 to 25°C.

Oxygen uptake was depressed in all isolates by reduced water potentials, however the response curve differed between the two species examined. The respiratory response of *C. graniforme* to increasing water stress is in agreement with previous studies on its ability to withstand drought.

STROMATA OF *Endothia* SPP. AS OBSERVED WITH THE SCANNING ELECTRON MICROSCOPE. D. N. Appel, M. K. Roane and R. J. Stipes. Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, Va 24061

Stromata formed by various members of the fungal genus *Endothia* were investigated with the scanning electron microscope. Preparation by fixation, dehydration and critical point drying was found to be successful in preserving surface characters of fresh tissue as well as 50 to 60-year-old herbarium specimens. Stromata of various *Endothia* species differ mainly in the degree of ostiolar development, ranging from slight (*E. gyrosa*) to long and conspicuous (*E. longirostris*). The size of stromal structures also varied among species. Some of the smallest were those formed by *E. parasitica*. Relative spore size and morphology were observed in specimens retaining spores. Although fungal characters revealed by scanning electron microscopy may not be definitive, they may prove to be useful adjuncts to gross morphology and cultural characters used in species delimitation.

RIBOSOMAL PROTEINS FROM MEGAGAMETOPHYTES OF SUGAR PINE SEED. L. B. Barnett, R. E. Adams, J. A. Ramsey\*, Dept. of Biochemistry & Nutrition and Dept. of Forestry & Forest Products, Virginia Polytechnic Institute & State University, Blacksburg, Virginia 24061.

Studies have shown considerable differences in the ability of the ribosomal fraction and soluble enzyme fraction from the tissues of the seeds of the sugar pine to support protein synthesis as this seed is stratified and germinated. Of particular interest is the observation that the ribosomal fraction from the megagametophyte tissue 1) will support protein synthesis in a cell-free system when the seed is dormant, 2) will not support protein synthesis after 90 days of stratification and 3) will support protein synthesis after germination. Slab gel electrophoresis has been performed on the ribosomal proteins from the megagametophyte at various stages to compare electrophoretic patterns, which may be related to ribosomal activity.



FIRST YEAR SURVIVAL OF UNDERPLANTED OAK SEEDLINGS IN MIXED HARDWOOD STANDS OF THE VIRGINIA PIEDMONT. C. L. Biestek\*, D. W. Smith\*, and P. P. Feret. Dept. of Forestry and Forest Products, Va. Polytechnic Inst., Blacksburg, VA 24061

Seedlings of white oak (*Quercus alba* L.), northern red oak (*Quercus rubra* L.) and eastern white pine (*Pinus strobus* L.) were underplanted in April, 1977 in mixed hardwood stands on the Virginia Piedmont and evaluated after one growing season.

Twenty-nine replications of forty-five (45) seedlings (15 of each species) were randomly planted on upland mixed-oak sites. Overstory stand parameters measured include: basal area, volume, age and growth rate, as well as soil type, percent slope, aspect and slope position. Survival, tallied by classes, live, dead, sprout with either live or dead top, and growth measurements were made in June and November, 1977.

After one growing season, 825 of the original 1305 seedlings were living, for an overall survival rate of 63%. The survival rate of white oak was 62%, red oak, 55% and white pine, 73%.

UPLAND HARDWOOD FORESTS IN PITTSYLVANIA CO., VIRGINIA. David Clark and Stewart Ware, Dept. of Biology, College of William and Mary, Williamsburg, Virginia 23185

Twenty-two upland hardwood forests in Pittsylvania Co., were sampled using the Bitterlich method for basal area and 10m diameter circles for density. Importance values were calculated and all stands were plotted on a two-dimensional vegetational ordination. Chestnut oak and white oak, concentrated in opposite corners of the ordination, were the most important species. Scarlet oak was third, partly overlapping and partly segregating from chestnut oak. Red maple, tuliptree, black oak, black gum, and sourwood were also important. Hickories only occasionally were important. Stands at the chestnut oak end of the ordination generally had gentler slopes, lower soil fertility, and slightly higher diversity. The low importance of northern red oak and high importance of scarlet oak and black oak contrast sharply with the findings of Gemborys (1974) in the upland forests of Prince Edward Co., in the central Piedmont of Virginia.

BELOW-GROUND BIOMASS IN FOUR PLANT COMMUNITIES OF THE GREAT DISMAL SWAMP, VIRGINIA. Katherine Montague\*, Dept. of Biology, Randolph-Macon Woman's Col., Lynchburg, Va. 24503 and Frank P. Day, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Below-ground biomass of four plant communities in the Great Dismal Swamp, Virginia was studied by excavating stratified random pits, .25 m<sup>2</sup> (.5 x .5 m) in surface area to a depth of 60 cm. Dry weight of below-ground plant parts from each 5 cm. depth increment was obtained. Analysis of data revealed vertical distribution of roots, total biomass per hectare of community root mass not associated with main root stocks, and percent contribution of roots of different sizes to total biomass. Subsurface biomass of the Mixed Hardwoods community (30,969 kg/ha) was found to be much greater than that of the other communities (Cedar, 17,857 kg/ha; Maple-Gum, 12,428 kg/ha; and Cypress, 15,300 kg/ha). Forty-seven percent of the underground biomass at the Cedar site and 46.5% of the biomass at the Mixed Hardwood site was located in the first 10 cm. of soil, the biomass at the other sites being less concentrated at the surface. Contribution to biomass in all communities from roots less than 0.3 cm. in diameter was significant, varying from 33.5% to 39.4% of the total biomass.

EFFECTS OF NUTRIENT COMPOSITION DURING LONG TERM GROWTH OF COTTON PLANTS IN CONTROLLED ENVIRONMENTS. Joyce G. Foster and John L. Hess. Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Cotton plants, *Gossypium herbaceum* var. "1697", propagated vegetatively were grown for 8 weeks in a 1:1 perlite:vermiculite mixture in a controlled environment growth chamber. Plants were maintained at 32° and 70% humidity with a 16 hr light/8 hr dark regime. Full strength nutrient solutions were supplied twice weekly at the rate of 500 ml/application.

Plants provided with Hoagland's nutrient containing iron citrate and nitrate as the sole source of nitrogen increased in height at a rate of 5 cm/week and produced normally pigmented leaves. Tissue remained in good condition with the exception of slight chlorotic spotting of older leaves after 4 weeks attributed to accumulation of soluble salts in the potting medium. In contrast, after 3 weeks of treatment, young leaves on plants maintained with Huffman's nutrient which contained Fe-EDTA and ammonia as the primary source of nitrogen were obviously chlorotic. Chlorosis progressed rapidly, and all leaves were affected after 5 weeks. As the pH of the potting medium decreased from 6.2 to 4.8 during the final 2 weeks of the experiment, moisture uptake and leaf production decreased and growth stopped. Brown flecks along veins and margins of leaves and, ultimately, death of plants resulted from nutrient imbalances. Analyses of leaf digests revealed comparable levels of Mn and Fe for the two treatments. (Supported by CSRS Grant 316-15-93).

ISOZYME PATTERNS OF SELECTED ISOLATES OF *PHOLIOTA* IN THE STIRPS *ADIPOSA*. U. K. Hotinen, A. E. Linkins, and O. K. Miller. Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

The species concept in *Pholiota*, stirps *Adiposa*, A. H. Smith & Hesler, has been investigated by applying electrophoretic techniques to isolates that have previously been examined for their morphology and mutual compatibility. Harvesting of different isolates for crude protein extraction was carried out at comparable stages of development using dry weight determinations and respiration studies as criteria. Soluble proteins were extracted from mycelium grown in liquid shake culture. Electrophoretically separated proteins were assayed for esterases (alpha-naphthylamidases), phenoloxidases (laccases and tyrosinases), and peroxidases. Peroxidases showed wide areas of activity and the intensity of the reaction was the only difference between isolates. Phenoloxidases showed slight differences between isolates of the two species studied. Esterase assay revealed an average of four active bands in each isolate, but the banding patterns in different strains suggested grouping that was not in agreement with the studies of the conventional taxonomy. The chemotaxonomic approach to the species complex of *Pholiota aurivella* (Fr.) Kummer and *P. limonella* (Pk.) Sacc. showed that the two species are closely related and cannot clearly be separated in this way.

ESTIMATES OF ABOVE-GROUND PHYTOMASS IN THE UNDERSTORY FOR APPALACHIAN OAK FORESTS IN THE RIDGE AND VALLEY PROVINCE OF VIRGINIA. W. L. Martin\*, T. L. Sharik and D. W. Smith, Dept. of Forestry and Forest Products, Va. Polytechnic Inst., Blacksburg, VA 24061

The study area was located on the midslope of Potts Mountain in Craig County, VA. Low moisture availability and the lack of nutrients in the soil limit productivity of these sites. Four major vegetation types were identified and can be represented along a decreasing moisture gradient as follows: (1) cove hardwoods with little or no ericaceous understory, (2) mixed oak with light to moderate ericaceous understory, (3) mixed oak pine with moderate to heavy ericaceous understory and (4) mixed pine with heavy heath understory. Estimates of understory phytomass indicate that substantial differences exist both between strata and between vegetation types.

Regression equations were developed by species and by vegetation type for above-ground phytomass using structural measurements as independent variables.

FOLIAGE DENSITY AS A MEASURE OF STAND STRUCTURAL RELATIONSHIPS IN THE RIDGE AND VALLEY PROVINCE OF VIRGINIA. T. J. McEvoy, T. L. Sharik, and D. W. Smith. Dept. of Forestry and Forest Products, Va. Polytechnic Inst., Blacksburg, VA 24061

Nine .16 ha study areas were established in Appalachian oak forests on Potts Mountain in Craig County, Virginia to assess vegetation structure and its relationship to differences in site. A number of structural parameters were measured by height strata to determine vertical stratification patterns. Foliage density was used in subordinate strata ( $\leq 5.0$  m) as a comparative measure of vegetative structure. The results indicate that the contribution of shrubs to vegetation structure is much higher on xeric than mesic sites, while trees are of greater significance on mesic sites. This suggests a proportionally higher utilization of site resources by subordinate strata on xeric sites. A cluster analysis of the study areas based on several structural parameters indicated that differences in stand structure may be associated with differences in available moisture. Foliage density in subordinate strata appeared to have some value as an integrator of vegetative structure on the study areas.

EXTRACELLULAR SOLUBLE AND BOUND CELLULASES INVOLVED IN GROWTH AND CELLULOSE DEGRADATION BY ACHLYA BISEXUALIS. W. H. Miele, A. E. Linkins. Dept of Biology, VPI & SU, Blacksburg, VA. 24061.

Achlya bisexualis was grown in chemically defined media using glucose and cellulose as carbon sources. Evaluation of growth and cellulase activity in the medium by viscometric and reducing sugar generation assays suggests that cellulase plays a significant role in degrading cellulose for uptake and catabolism. Cellulase in glucose grown cultures exists as a soluble extracellular enzyme complex, while in cellulose cultures much of the enzyme is adsorbed to the cellulose. Elution of the remaining cellulosic substrate with NaCl fortified buffer releases adsorbed cellulase in a soluble form. Comparative electron microscopic examination of accumulated mycelia grown on glucose and cellulose shows declining dry weights in cellulose cultures after 96 hours can be attributed to losses in cell wall thickness.

Attempts to elucidate differences between soluble and bound proteins have shown increased bound protein with greater  $\beta$  1-4 exoglucanase activity in cellulose cultures and increased levels of soluble protein having greater  $\beta$  1-4 endoglucanase activity in glucose cultures.

THE ECOLOGY OF CORTICOLOUS LICHEN COMMUNITIES AT VARIOUS ALTITUDES ON SALT POND MOUNTAIN, GILES COUNTY, VIRGINIA. Marguerite P. Morris\*, O. K. Miller, Jr., and Judith Croxdale. Dept. of Biology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

A study was conducted of the corticolous lichen community of Quercus rubra on the southeast face of Salt Pond Mountain, Giles County, Virginia. These communities were examined according to altitude, vertical level on the tree, total lichen cover, lichen growth form composition, and the presence and abundance of foliose and fruticose species. Moss percentage cover was also estimated in situ as an indicator of available moisture trends.

The results of this study indicate that, with the exception of fruticose lichens, the character and species composition of this lichen community does not vary directly in accordance with altitude. Most of the 38 foliose and fruticose lichen species examined exhibited their greatest frequency and abundance at a preferred vertical height above the ground. These lichen communities appear to lack the characteristics of those disturbed by atmospheric sulfur dioxide.

COMPARISON OF THE LIPID COMPOSITION OF FIVE SPECIES OF MISTLETOE. D. M. Orcutt and C. L. Calvin.\* Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, VA 24061 and Dept. of Biology, Portland State Univ., Portland Oregon 97207.

The sterol, fatty acid, and hydrocarbon composition of four species of Arceuthobium and two species of Phoradendron were compared. The major sterol in all species was sitosterol. Varying amounts of cholesterol and campesterol were also detected. Stigmasterol was detected only in Phoradendron serotinum.

All species analyzed contained 16:0, 16:1, 18:0, 18:1, 18:2, 18:3, 20:0, and 22:0 as the major fatty acid components. Concentrations of 18:1 and 18:2 were consistently higher than other fatty acids detected. Quantitative differences in fatty acid concentration were noted among species.

Hydrocarbons ranged in carbon length from C-16 to C-34 in all species. Species of Arceuthobium generally had C-29 or C-31 as their major hydrocarbon components while Phoradendron had C-25, C-28, C-30 or C-27 as the major components.

Comparison of male and female plants for the above components showed little qualitative difference, but female plants were generally higher in concentrations of lipid components than male plants.

VEGETATION AND EPAPHIC FACTORS IN SMALL STREAM SWAMPS OF THE VIRGINIA COASTAL PLAIN. Susan Parsons and Stewart Ware, Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185.

Vegetational composition, soil texture, soil mineral content, soil pH, soil moisture content, and flooding levels were studied in 14 small stream bottoms in the central Coastal Plain of Virginia. High summer soil moisture levels, high Ca, high Mg, high N, and high pH were all found in stands dominated by Fraxinus pennsylvanica, Acer rubrum, and Ulmus americana. In stands of this type which were frequently flooded, Taxodium distichum became an important associate. Stands with some dry periods in the summer were more variable in composition, but often had Carpinus caroliniana and Liquidambar styraciflua as important species. Some stands of this more acid, low Ca, summer dry type had heavy flooding during the wetter parts of the year, and in these Quercus phellos was important. Duration of flooding and soil moisture between floods were far more important in controlling vegetation than frequency of flooding or depth of flooding.

TREE-RING RESPONSE OF LOBLOLLY PINE TO HYDROLOGIC CHANGE AND CLIMATE. R. L. Phipps and D. L. Ierley\*, Tree-Ring Lab., U. S. Geological Survey, Reston, Va. 22092

Ring widths of loblolly pines (Pinus taeda) growing near a drainage ditch in the Great Dismal Swamp were analyzed and compared with climatic factors for periods prior to and following ditch construction. Results from regression analysis indicated that prior to ditching, growth was most limited by dry summers which followed dry summers. Relative to growth responses prior to ditching, growth after ditch construction was less strongly linked with precipitation and more strongly linked with temperatures. Climatic and prior growth factors in regression explained 87 percent of the variance of earlywood widths and 82 percent of the variance of latewood widths for the period prior to ditching. It was concluded that a change in hydrologic conditions following ditch construction resulted in rainfall and temperature having limited growth to different degrees.



OBSERVATIONS OF ISOLATES OF *ENDOTHIA GYROSA*, *E. PARASITICA* AND *E. RADICALIS*. Martha K. Roane and R. Jay Stipes. Dept. of Plant Pathology & Physiology, Virginia Polytechnic Institute & State University, Blacksburg, Va. 24061

Cultures of *Endothia gyrosa* (CBS 165.32, 250.54, 253.54), *Endothia gyrosa* (CBS 113.13), *Endothia parasitica* (CBS 114.13, 242.54, 247.54) and *Endothia radicalis* (CBS 116.13, 117.13, 238.54, 239.54, 240.54) were compared with cultures of *Endothia gyrosa* (CBS 509.76, 510.76), *Endothia parasitica* (E-88, E-96), *Endothia radicalis* (GJS 73.79, 73.146) and *Endothia tropicalis* (F. D. 135/62, GJS 73.259) isolated from ascospore voucher material. Criteria for comparison were growth (mycelial dry weight) on glucose-yeast extract broth at 4 temperatures for 4 time periods, production of a guaiacol-like odor on glucose-yeast extract agar, color produced beneath colonies grown on white corn meal, and kinds of bisanthraquinones produced. There appear to be 5 groups in the 20 cultures: A.) CBS 113.13, 238.54, 247.54; B.) F.D 135/62, GJS 73.79, 73.146, 73.259, CBS 249.54, 250.54; C.) CBS 114.13, 117.13, 242.54, E-88, E-96; D.) CBS 116.13, 509.76, 510.76; E.) CBS 165.32, 240.54, 253.54. Group E contains 3 cultures which differ from each other and every other culture while the other four groups are fairly homogeneous.

HORMONAL EFFECTS ON THE GROWTH AND POTASSIUM CONTENT OF *LEMNA*. Rosemary Smith\*, and P.T. Nielsen. Dept. of Biology, James Madison Univ., Harrisonburg, VA 22801

Axenic cultures of *Lemna perpusilla* strain 67h6 were grown on 20% Hutner's inorganic nutrient medium under a 18:6 hour photoperiod of 90 microeinsteins per m<sup>2</sup> sec<sup>-1</sup> (400-700nm). Temperature was on a timed cycle, 25°C during the light period and 18°C during the dark.

Experiments were designed to test the effects of varying concentrations of kinetin and abscisic acid on the growth and accumulation of potassium by *Lemna*, during the exponential phase of growth. Growth was measured as increase in the number of fronds from an original three frond colony, and as dry weight. The potassium content was determined by flame emission spectrophotometry.

Kinetin at 0.2uM and 2.0uM had no significant effect on potassium content; however, the lower concentration did increase growth significantly (99% level). Kinetin at 20.0uM inhibited growth to 44% of the control, and decreased potassium content to 22%.

Abscissic acid (<sup>3</sup> ABA) at 5.0 and 10.0uM strongly inhibited growth and potassium accumulation, while 1.0uM was slightly less effective. ABA at 0.1uM acted as a weak inhibitor. Inhibition by 1.0uM ABA was not affected by the presence of 0.2uM kinetin. Upon transferral of *Lemna* from 1.0uM ABA medium to 20% Hutner's medium, growth and potassium accumulation returned to normal.

CHANGES IN CELLULOSE ENZYME PATTERNS DURING INDUCED LATERAL BRANCHING IN *ACHLYA BISEXUALIS*. L. A. Stein\*, A. E. Linkins. Dept. of Biology, VPI & SU, Blacksburg, VA. 24061.

Anteridial branching in *Achlya bisexualis* is hormonally regulated. It has been reported that casein hydrolysate in the media mimics this hormonal stimulation of branching; concomitant with this is an increase in cellulase activity. Our work has confirmed casein hydrolysate stimulation of branching. These increases in activity have been confirmed on both a per mg total intracellular and extracellular protein basis as well as per gram dry weight organism. Cellulase associated with branching is 1-4 endoglucanase. It is hypothesized that endoglucanase activity associated with branching is different from that associated with cellulose hydrolysis in the culture media.

ANTHRACNOSE OF ACER PLATANOIDES IN VIRGINIA. R. J. Stipes and G. L. Clement, Dept. of Plant Pathology & Physiology, VPI & SU, Blacksburg, VA 24061.

For several years, the senior author has observed anthracnose-type lesions on Norway maple (*Acer platanoides*) in Virginia. Type specimens were obtained at Martinsville (M) and Waynesboro (W) for detailed study. Lesions were visible on abaxial and adaxial leaf surfaces, variable in size and shape, dark brown and sometimes with a tan center, and commonly (but not always) clustered around major veins in the lobar regions. Some lesions occurred almost exclusively on the veins. Glucose-yeast extract agar cultures of biopsied lesions were almost pure and strikingly similar to *Glomerella cingulata*, the bitter rot of apple pathogen. Aerial mycelia were smoky gray-green with a purple mycelial pigment produced in the agar. Salmon-orange colored conidial masses were produced in a few scattered acervuli. The conidial size ranges with averages were 12.5-17.5 X 3.75-6.25 µm (av. 14.5 X 4.7 µm) for the M isolate, 10-16.25 X 3.75-6.25 µm (av. 12.9 X 4.7 µm) for the W isolate as compared to 10-35 X 3.5-7 µm (av. 12-16 X 4-6 µm) for isolates from apple. Both M and W isolates produced typical bitter rot lesions on apple. Although the perfect stages of M & W isolates were not observed, morphological data of the imperfect stage (*Gloeosporium*) together with their pathogenic attributes strongly suggest that this anthracnose pathogen of Norway maple in Virginia is *Glomerella cingulata*.

FOREST SUCCESSION IN SHENANDOAH NATIONAL PARK, VIRGINIA. D. L. Stoltzfus\* and W. D. Cocking. Dept. of Biology James Madison University, Harrisonburg, Va. 22801

Since the establishment of Shenandoah National Park in 1935, the areas inhabited by man at that time have been left undisturbed. Six sites were selected at each of 720 m and 900 m elevations on northwest and southeast facing slopes which at that time were fields or pastures. Vegetation in these year 40+ old-field sites was sampled quantitatively. Importance values were calculated, and major species are listed in descending order. Within each species, maximum relative importance occurred on different altitude and slope exposure combinations as indicated in the following table.

Species	Mean I.V.	NW-720	NW-900	SE-720	SE-900
<i>Robinia pseudoacacia</i>	35.9 %				X
<i>Fraxinus americana</i>	10.9		X		
<i>Prunus serotina</i>	10.0				X
<i>Acer rubrum</i>	8.2	X			
<i>Leriodendron tulipifera</i>	4.7	X			
<i>Cornus florida</i>	5.6	X		X	
<i>Sassafras albidum</i>	3.6			X	
<i>Crataegus</i> spp	3.3		X		X
<i>Pinus</i> spp	3.1			(X)	X
<i>Carya</i> spp	2.9	X			
<i>Ailanthus altissima</i>	2.4			X	

Analysis of the age structure of tree species populations is used to determine the successional order of species establishment and give an indication of the rates of secondary succession in the different habitats.

THE PHYSIOLOGICAL ECOLOGY OF FIREPLACE FUNGI ASSOCIATED WITH PRESCRIBED BURNS AT TALL TIMBERS RESEARCH STATION, FLORIDA. J. Vinopal, O.K. Miller. Va. Polytechnic Inst., Blacksburg, Va., 24060. and E.V. Komarek. Tall Timbers Research Station, Route 1, Tallahassee, Fla., 32303.

Prescribed burning has been a major factor in determining the flora of the southeastern ecosystem. The occurrence of Ascomycete and Basidiomycete fruiting bodies on areas subjected to prescribed burning was investigated. The top mineral soil layer from these same areas was analyzed and found to fluctuate in pH as a direct result of the time since the last burn and the frequency of burning.

The growth responses of selected species to pH values in the range of 4.0 to 8.5 was also investigated. Four species of well documented fireplace Ascomycetes and Basidiomycetes representing a wide range of ecological preferences for burned areas were used. Ascomycetes and saprophytic Basidiomycetes were grown on a modified Nobles media (2% malt and 2% agar); mycorrhizal Basidiomycetes grew best on a 1% malt, 1% glucose, and 2% agar media. Linear growth and percent spore germination were measured.

The fungi showing the greatest dependence on burns for fruiting body initiation had faster growth rates, a tendency to grow over a wider range of pH values, and the ability for growth at higher pH values, than those species showing less dependence on burned areas for fruit body initiation. ( Supported by the Gerald Beadel Scholarship Fund, Tall Timbers Research Station, Tallahassee, Fla. )

## Section of Chemistry

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

LABORATORY SAFETY PROGRAM IN AN UNDERGRADUATE CHEMISTRY DEPARTMENT. Robert C. Atkins, Dept. of Chemistry, James Madison University, Harrisonburg, Va. 22801

The activities undertaken in the area of laboratory safety at JMU will be described. These include: the acquisition of safety equipment; introduction of safety to beginning students; a seminar course in laboratory safety for upper level chemistry and biology majors. Discussion will also center on areas where changes or improvements might be made.

ISOLATION OF PROSTAGLANDINS FROM THE JELLYFISH *CHRYSAORA QUINQUECIRRHA*. Charles E. Bell, Jr. and Donna L. McGovern, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

Samples of the medusa of the jellyfish *Chrysaora quinquecirrha* were collected during July and August of 1977. The gastric and gonadal regions were homogenized in an equal volume of methanol-chloroform (1:1), and the chloroform layer was collected, dried, and evaporated to dryness. Two dimensional thin layer chromatography on silica gel plates (0.25 mm) revealed spots which had  $R_f$  values corresponding to authentic samples of PGA and PGB or derivatives. Infrared spectra of preparative TLC samples confirm the existence of hydroxyl (broad  $3450\text{ cm}^{-1}$ ), two carbonyls ( $1730\text{ cm}^{-1}$  and  $1675\text{ cm}^{-1}$ ), and alkene ( $1620\text{ cm}^{-1}$ ). Applying the above separation procedure to a mixture of a wide selection of authentic lipid classes including prostaglandins resulted in the isolation of the prostaglandin fraction in reasonably good yield.

EFFECTS OF SAPONIFICATION ON THE RECOVERY OF STEROLS AND STEROL ESTERS. B. Bradford, L. D. Moore and D. M. Orcutt. Dept. of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

The recovery of sterols and sterol esters was determined after treatment with KOH at the following concentrations: 10, 7, 3, 1 and 0.3%. A stock solution containing either sterols (cholesterol, campesterol and stigmasterol) or sterol esters (cholesteryl laurate, cholesteryl palmitate and cholesteryl myristate) was measured into a series of screw cap tubes, and the solutions were dried under nitrogen. The concentrations of KOH in 9:1 methanol:water were added to the tubes, and all treatments were heated at  $65^\circ\text{C}$  for 1 h. Each treatment was partitioned with hexane, the hexane was drawn off and dried under nitrogen. The hexane fraction containing three sterols or the cholesterol freed from the three cholesterol esters was derivatized utilizing BSA and quantitated on a Bendix 2600 gas-liquid chromatograph utilizing a 1 m SE-30 column. The recovery of sterols was generally low, but the recovery was significantly lower ( $P=0.05$ ) in the KOH treatments than in the controls. Results indicate that differential sensitivity of individual sterols may lead to significantly different levels of recovery. The recovery of cholesterol from cholesterol ester was 75% higher ( $P=0.05$ ) after KOH treatment than without KOH treatment.

EFFECTS OF ACID HYDROLYSIS ON THE RECOVERY OF STEROLS AND STEROL ESTERS. B. Bradford, L. D. Moore and D. M. Orcutt. Dept. of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

The recovery of sterols and sterol esters was determined after treatment with HCl at the following concentrations: 6.0, 3.0, 1.0, 0.5 and 0.1 N. The sterols were cholesterol, campesterol and stigmasterol. The sterol esters were cholesteryl laurate, cholesteryl palmitate and cholesteryl myristate. One ml of a stock solution of sterols or sterol esters was measured into each of a series of screw cap tubes and dried under nitrogen. The concentrations of HCl in 4:1 methanol:water were added to the tubes and were heated at  $65^\circ\text{C}$  for 4 h. Each treatment was partitioned in hexane. The hexane containing the sterols was drawn off and dried under nitrogen. The free sterols and the cholesterol freed from the sterol esters were derivatized utilizing BSA for 45 min at  $55^\circ\text{C}$  and quantitated on a Bendix 2600 gas-liquid chromatograph utilizing a 1 m SE-30 column. There was a significant ( $P=0.05$ ) reduction in the percent recovery of free sterols at 6.0 and 3.0 N HCl. This response indicated that a destruction of the sterols may be occurring. There was a significant ( $P=0.05$ ) differential effect of the procedure on the recovery of the individual sterols.



ENERGY TRANSFER IN LANTHANIDE COMPLEXES OF PYRIDINE-CARBOXYLIC ACIDS. H. G. Brittain, Dept. of Chemistry, Ferrum College, Ferrum, Va. 24088

Lanthanide complexes of picolinic, nicotinic, and dipicolinic acids have all been studied using emission spectroscopy, lifetime of emission measurements, and pH titrations. In addition, energy transfer from Eu(III) to Tb(III) has been investigated. All of these measurements enable a description of the solution environment about the lanthanide ion when it is complexed to each of the pyridine-carboxylic acids. At high pH, the lanthanide complexes of dipicolinic acid are monomeric and discrete, but probably are somewhat associated at lower pH values. Complexes of picolinic acid are found to be associated at all pH values. It was also concluded that picolinic acid can act as a bidentate ligand, dipicolinic acid can act as a bidentate ligand at low pH and terdentate at high pH, and that nicotinic acid only functions as a monodentate ligand. The energy transfer process was found to require the presence of mixed Tb(III) - Eu(III) complexes in some sort of polymeric association in solution. (Supported by the Research Corporation)

SYNTHESIS, STRUCTURE, AND PROPERTIES OF A NEW TYPE OF TRI-NUCLEAR ANTIFERROMAGNETIC COPPER (II) COMPLEX. R. J. Butcher\* and E. Sinn, Chemistry Department, University of Virginia, Charlottesville, VA 22901 and Howard University, Washington, D.C. 20059\*.

A new series of copper(II) carboxylate complexes has been synthesized and characterized by magnetic and crystallographic measurements. The compounds can be formed by reacting copper(II) haloacetates with copper(II) complexes of Schiff Base (SB) ligands. The general structure is unique among copper complexes, and contains a central OH group bonded to each of three metal atoms, which are in turn bridged by two carboxylate groups. The general formula is  $[\text{Cu}_3(\text{OH})(\text{SB})_3(\text{RCOO})_2]$ . Each copper atom couples antiferromagnetically with its two neighbors.

MORE STRANGE ASPECTS OF POLY G·POLY C. R. O. Carter and T. O. Sitz, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

In an ongoing research effort to describe the extent of the interaction of guanidine with cytosine in RNA molecules we have tried to characterize the size of a commercial source of poly G and poly C. In so doing several yet undescribed behaviors of these species have been found. In addition, contrary to previous reports our data from both gelfiltration chromatography and ultracentrifugation studies indicated that the poly G is larger than poly C in the lots that have been obtained. These results were obtained in a 10% water-dimethylsulfoxide solvent system which has been found to be denaturing with respect to secondary structure while leaving these polymers intact. In addition an interaction was found between small molecular weight  $^3\text{H}$ -labeled RNA species and poly C in the centrifugation studies using 10% water-dimethylsulfoxide solvent system. No such effect was observed for poly G.

THE VIBRATIONAL INFRARED SPECTRUM OF THE GROUP IVB TRANSITION METAL MONONITRIDE GASEOUS MOLECULES. T. C. DeVore and T. N. Gallaher\*, Dept. of Chemistry, James Madison University, Harrisonburg, Va. 22801

The infrared spectrum of the TiN, ZrN and HfN molecules has been observed in absorption by using a microwave discharge through metal halide/nitrogen mixtures as the molecular source. The molecular constants for each molecule are

	TiN	ZrN	HfN
$\nu$ ( $\text{cm}^{-1}$ )	969.6(1)	936.6(1)	915.2(2)
$B_0$ ( $\text{cm}^{-1}$ )	0.623(6)	0.483(4)	0.457(9)
$\alpha_e \times 10^3$ ( $\text{cm}^{-1}$ )	4.08 (1)	3.01 (3)	1.02 (6)
$r_e$ ( $\text{cm}^{-1}$ )	0.158(1)	0.170(1)	0.169(3)

The agreement between the rotational constants observed here and the rotational constants reported previously for TiN and ZrN, establishes that these molecules have  $^2\Sigma$  ground states. The lack of a Q branch in the infrared spectrum of HfN indicates that the ground state of HfN is also  $^2\Sigma$ .

PRESSURE DEPENDENCE OF THE POSITION OF THE NITRO-NITRITO EQUILIBRIUM. J. R. Ferraro\*, P. G. Sim\*, and E. Sinn, Argonne National Laboratory, Argonne, Illinois and Chemistry Department, University of Virginia, Charlottesville, Virginia 22901.

The nitrite anion may coordinate to metals in a number of different fashions, acting as a monodentate, a bidentate or a bridging bidentate ligand. When acting as a monodentate ligand, it may bond either through N(nitro-) or O(nitrito-). It has been noted that complexes formed by the reaction of nickel nitrite with C- or N-substituted ethylenediamines may be either red (nitro) or blue(nitrito), the particular isomer formed depends upon the nature of the amine substitution. A solution equilibrium between the nitro and nitrito form of  $\text{Ni}(\text{N,N}'\text{-diethylethylenediamine})_2(\text{ONO})_2$  has been observed. We have found, using infrared spectroscopy, a pressure-dependent equilibrium between the nitro and nitrito forms of solid  $\text{Ni}(\text{pyridine})_4(\text{ONO})_2$ .

THE MAGNETIC AND VIBRATIONAL PROPERTIES OF  $[\text{Fe}(\text{cHx}_2\text{dtc})_3][\text{FeCl}_4]$ . A. Greenaway\* and E. Sinn, Department of Chemistry University of Virginia, Charlottesville, Virginia 22901

The ionic solid  $[\text{Fe}^{\text{IV}}(\text{N,N dicyclohexyldithiocarbamate})_3](\text{Fe}^{\text{III}}\text{Cl}_4)$ , prepared in anhydrous solvents from  $\text{Fe}(\text{N,N dicyclohexyldithiocarbamate})_3$  and  $\text{FeCl}_3$ , has been characterized by its elemental analysis, infrared spectrum and magnetic moment. The magnetic moment contribution from the cation is different from that found when the anion is diamagnetic and indicates the existence of anion-cation magnetic interactions.

GAS CHROMATOGRAPHIC ANALYSES OF PROSTAGLANDIN FRACTION OF THE LIPIDS OF CHRYSAORA QUINQUECIRRHA. Charles E. Bell, Jr. and Thomas J. Haas, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

Standard methods have been used to confirm the identity of lipid fractions of Chrysaora quinquecirrha isolated by preparative thin layer chromatography. Trimethylsilyl derivatives, acetates, and methyl esters of  $\text{PGA}_2$ ,  $\text{PGB}_1$ ,  $\text{PGE}_2$ ,  $\text{PGF}_{1\alpha}$ , and  $\text{PGF}_{1\beta}$  were prepared for comparison purposes. Tentative identification of two prostaglandin compounds has been made.

SOME NEW APPROACHES TO THE SYNTHESIS OF INDOL-4,5-QUINONES. Jane L. Marcus\*, Elizabeth K. Saunders\*, and James B. Patrick. John Baker Daffin Lab. of Chemistry, Mary Baldwin Col., Staunton, Va. 24401

Oxidation of 5-hydroxy-6-prenylindoles by Frey's Salt (potassium nitrosodisulfonate), the most commonly used method of converting 5-hydroxyindoles to indolo-4,5-quinones, fails because of the exceptionally low water solubility of the substrates. Attempts to circumvent this difficulty by modifications of the oxidation conditions, by solubilization through the use of crown ethers, and by phase-transfer catalysis are described. Other known methods for transforming 5-hydroxyindoles to indolo-4,5-quinones are briefly reviewed and their applicability to the 5-hydroxy-6-prenylindoles is assessed. Finally, we report investigations of a new sequence for effecting the conversion of 5-hydroxyindoles to indolo-4,5-quinones by way of the previously undescribed 4-nitroso-5-hydroxyindoles.

THE PROPERTIES OF THE COENZYME-BINDING SITE OF CHICKEN MUSCLE L- $\alpha$ -GLYCEROPHOSPHATE DEHYDROGENASE, G. Dean Howell\*, and James H. Yuan, Dept. of Chem. Sciences, Old Dominion University, Norfolk, Va. 23508

L- $\alpha$ -Glycerophosphate dehydrogenase from chicken breast muscle was purified with a saturation-readsorption technique on an affinity column of 8-(6-aminoethyl)-amino-AMP-Sepharose. The properties of the coenzyme-binding site of the purified enzyme were studied by inhibitor analysis and multiple inhibition technique. The presence of adenosine, pyrophosphate, hydrophobic and pyridinium ring regions at the coenzyme-binding site of the L- $\alpha$ -glycerophosphate dehydrogenase was suggested.

Furthermore, the involvement of the hydrophobic region of the coenzyme-binding site in the anti-cooperative interaction between two coenzyme binding sites of the enzyme dimer was observed with various coenzyme competitive inhibitors such as 3-aminopyridine adenine dinucleotide and ADP-ribose. The details of these studies will be presented.

SYNTHESIS OF FLUORINATED  $\alpha$ -DIKETONES. M. Hudlicky. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

As a part of a program for the preparation of heat-resistant fluorinated polymers, syntheses and some reactions of polyfluorinated  $\alpha$ -diketones  $\text{C}_6\text{H}_5\text{COCOC}_3\text{F}_7$  and  $\text{C}_6\text{H}_5\text{COCOC}(\text{CF}_2)_4\text{COCOC}_6\text{H}_5$  have been investigated. The best approach was the oxidation of monoketones of the general formulae  $\text{C}_6\text{H}_5\text{CH}_2\text{COC}_3\text{F}_7$  and  $\text{C}_6\text{H}_5\text{CH}_2\text{CO}(\text{CF}_2)_4\text{COCH}_2\text{C}_6\text{H}_5$  which in turn were prepared by Grignard syntheses. The effects of different components in the Grignard reaction such as benzylmagnesium chloride, dibenzylcadmium, acyl halides, acids, acid salts, nitriles, etc. on the yields of the reaction were established. Selenium dioxide was used for the conversion of the ketones to the yellow  $\alpha$ -diketones. These form readily white crystalline hydrates in which only one of the two vicinal carbonyl groups is hydrated, most probably the one adjacent to the fluorinated clusters. The work was supported by NASA Langley Grant NAS1-13175.

A THERMODYNAMIC STUDY OF THE INTERACTION OF HYDROGEN CHLORIDE WITH SILICA. Yoon Kang\* and J. P. Wightman, Chem. Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The adsorption of hydrogen chloride on Min-U-Sil 5, a microcrystalline silica, has been studied in a constant volume system as a function of outgassing temperature and pressure. Hydrogen chloride adsorption isotherms were determined at 303 K for silica outgassed at 373 K and 473 K in vacuo for 2 hours. The isotherms were determined over a wide pressure range. Partial reversibility of hydrogen chloride adsorption was established by evacuation of silica at room temperature after adsorption followed by a re-adsorption determination. The ESCA spectra of silica was obtained for C, O, Si and Cl photopeaks before and after exposure to hydrogen chloride. The heats of wetting of silica in hydrochloric acid solutions of varying concentration were determined at 310 K. The results suggest some irreversible adsorption of hydrogen chloride on silica but without extensive chemical reaction leading to dissolution of the silica. [Work supported under NASA Grant NSG-1389].

AGAROSE GEL PROCEDURES FOR THE ANALYSIS OF VIRAL RNA. J. M. Keller\*, T. O. Sitz, and K. D. Somers, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508 and Dept. of Microbiology, Eastern Virginia Medical School, Norfolk, Va. 23508

In studying small differences in relative mobilities of denatured 70s viral RNA we have employed a high resolution agarose-urea gel system. The agarose-6M urea gel procedure used is a modification of a procedure first introduced by Rosen *et al.* (Biochemistry (1975)14,69-78). The major criticism of Rosen's procedure was that the low pH used in his gels (pH 3.5), resulted in selective protonation of adenine and cytosine which caused a change in the charge/mass ratio. It has been stated that this selective protonation is required for achieving the high resolution observed with the gel (Lehrach, *et al.*, Biochemistry (1977)16,4743-4751).

It has been our observation that the low pH conditions for the agarose-urea gel is not required to achieve high resolution, in fact, best resolution has been obtained at a pH 7-7.8. Studies are presently involved with a better characterization of the agarose-urea gel system.



SHAKE-UP SATELLITES IN ESCA SPECTRA. T. J. Kelly\* and J. C. Schug, Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The sudden approximation is used to calculate satellite intensities for x-ray photoelectron spectra. Single-configuration INDO wavefunctions are used. Calculated results for several polymer repeat units are compared with experimental ESCA spectra of those polymers.

For substituted benzenes, satellite intensities for ionization of ring carbons are much larger than those for ionization of substituent carbon atoms. Furthermore, ring carbon satellite intensities are much larger in substituted phenols than in alkyl benzenes.

MODELLING BIFUNCTIONAL ESTER EQUILIBRIA USING BINOMIAL STATISTICS. R. B. Lam\*, F. A. Palocsay, and J. J. Leary, Dept. of Chemistry, James Madison Univ., Harrisonburg, VA 22801.

A mathematical model based on the binomial distribution was developed to describe the methanolysis of diethyl esters as a function of the amount of methanol present in the initial reaction mixture. The model can predict relative amounts of diethyl, ethylmethyl, and dimethyl esters present at equilibrium as well as an equilibrium constant describing the overall reaction.

Experimental verification of the model was carried out by gas chromatographic analysis on equilibrium mixtures of methanolysis reactions with bifunctional esters. Three esters, diethyl-oxalate, diethylmalonate, and diethylsuccinate, were chosen for the experiment. Equilibrium molar ratios of diethyl, ethylmethyl, and dimethyl esters and equilibrium constants were calculated and compared to the theoretical values of the model.

Deviations from the ideality assumptions of the model are discussed. The model is also shown to be easily extended to include polyfunctional esters.

COMPUTER-AIDED INSTRUCTION IN BIOCHEMISTRY. AN INTERACTIVE PROGRAM TO HELP STUDENTS UNDERSTAND ANAEROBIC GLYCOLYSIS. C. E. Lamb\* and W. H. Voige, Dept. of Chemistry, James Madison Univ., Harrisonburg, Va. 22801.

We have written a self-paced tutorial computer program which supplements lecture and text book material in an undergraduate biochemistry course. The goal of the program is to help students see the relationships between (1) the step-wise nature of glycolysis, (2) the names and structures of reactants/products in each step, and (3) the names of the enzymes which catalyze the reactions. The program is a series of fifty-three questions. If a student's response to a question is correct, he receives a message which reinforces his learning. An incorrect response yields a hint, and the question is repeated.

The program has several unique features. (1) Questions are of three types: multiple choice, true-false, and short (one word) answer. (2) At key reactions, structures of reactants/products are shown. (3) If a student needs a hint, he can receive one by typing HELP.

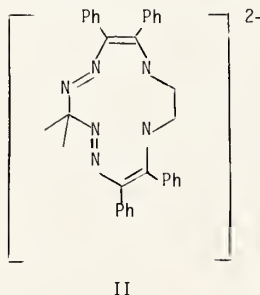
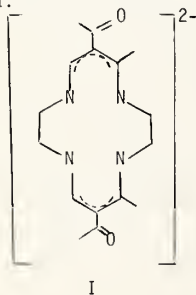
The program is written in Hewlett-Packard 3000 series BASIC. It can use teletype or CRT input and output.

SAFETY ORIENTATION FOR ADVANCED STUDENTS AT V.P.I. & S.U. J. G. Mason, Dept. of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

The current program for safety training and supervising graduate students and advanced undergraduate students will be presented with emphasis on its defects and modest successes.

KINETICS AND MECHANISM OF FORMATION OF SOME COMPLEXES CONTAINING TETRAAZA MACROCYCLIC LIGANDS. Gordon A. Melson, Craig A. Reider, Martha A. Brumfield and Suzanne L. DeLoach. Department of Chemistry, Virginia Commonwealth University, Richmond, VA 23284

The paper will present recent results on the kinetics and mechanism of formation of nickel(II) and copper(II) complexes of the macrocyclic ligand, I and of nickel(II) complexes of II.



New, improved syntheses of macrocyclic complexes containing the above ligands have been developed by the application of the mechanistic information; these syntheses will be discussed.

SAFETY AND LIABILITY IN THE ACADEMIC CHEMISTRY LAB. W. H. Myers\*, Dept. of Chemistry, Univ. of Richmond, VA, 23173, and R. B. Scott, Jr.\*, Dept. of Chemistry, Univ. of Mississippi, University, MS, 38677. (Presented by R. M. Ottenbrite, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, VA.)

As a result of the experiences involved in an accident in 1972 and a subsequent lawsuit in 1976, both involving a faculty member at the Univ. of Mississippi, we will report on legally important precautions which chemistry departments and their faculties ought to consider taking prior to, during, and following serious incidents which may occur in an academic chemistry laboratory. Some discussion will also be made of the potential liability to which a chemical educator is exposed in the course of his work.

MAGNETIC EXCHANGE INTERACTIONS IN TETRANUCLEAR COPPER II COMPLEXES. EFFECT OF LIGAND ELECTRONEGATIVITY. C. J. O'Connor\*, H. Wong\*, H. tomDieck\* and E. Sinn, Chemistry Department, University of Virginia, Charlottesville, VA 22901

Magnetic susceptibility measurements are reported for a series of tetranuclear copper(II) complexes  $\text{Cu}_4\text{O}_6\text{L}_4$  ( $\text{X} = \text{Br}, \text{Cl}; \text{L} = \text{Cl}, \text{Br}, \text{C}_6\text{H}_5\cdot\text{CH}_2\text{CN}, \text{C}_5\text{H}_5\text{N}, \text{C}_5\text{H}_5\text{NO}, \text{tetra-methylurea and dimethylsulfoxide}$ ). These data and literature data on two tetranuclear complexes, describe a range of magnetic behavior, varying from strong intramolecular antiferromagnetic interaction, through weak antiferromagnetic interaction. Intermolecular interactions are found to be negligible. The results are used to evaluate current theoretical models for such systems, and are consistent with the existence of a significant antisymmetric component in the pairwise exchange Hamiltonian.

ANALYSIS AND STUDY OF FACTORS RELATED TO THE STABILITY OF HIGH ENERGY LITHIUM-SULFUR DIOXIDE BATTERIES. Donald M. Oglesby, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va., 23508, and James Bene\*, NASA, Langley, Hampton, Va.

It has been found that lithium-sulfur dioxide cells having lithium bromide in acetonitrile as the electrolyte will explode if discharged into current reversal at low temperatures. Analysis of the reactions taking place in the cell indicate that the explosion is initiated by the reaction of lithium metal formed at the cathode after depletion of the sulfur dioxide in the vicinity of the cathode. Cyclic voltammetry was used to elucidate the difference between the stability of cells discharged at low temperature vs. those discharged at high temperature.

STUDIES ON THE NENITZESCU SYNTHESIS OF 5-HYDROXYINDOLES. II. James B. Patrick, Elizabeth K. Saunders\*, and Jane L. Marcus\*, John Baker Daffin Lab. of Chemistry, Mary Baldwin Col., Staunton, Va. 24401

Our previous results on improving the yields of the Nenitzescu synthesis of 5-hydroxyindoles can be rationalized, to a considerable extent, by postulation of an intermediate face-to-face "sandwich" electron transfer complex. The formation of such a complex is likely to be sensitive to steric effects from the substituents on the two components. The comparative yields of various substituted 5-hydroxyindoles prepared under identical reaction conditions are discussed from the point of view of the specific nature and orientation of the postulated complex. A number of anomalies are noted in the data, however, and some possible lines of future investigation are projected to resolve the remaining questions.

ATOMIC SPECTROSCOPY AS A TOOL OF ARTIFACT ANALYSIS IN HISTORIC SITE ARCHAEOLOGY. Mike Pleva (sponsor member), Mark Derbyshire, and John McDaniel, Washington and Lee Univ. Lexington, Virginia 24450.

Two atomic spectroscopic techniques were employed in the analysis of artifacts from the Liberty Hall Archaeological Program. A characterization of metal button artifacts was accomplished by Atomic Absorption Spectroscopy, while the Emission Spectrographic analysis of ceramic artifacts served to underscore the complexity and chemical similarity of ceramic fragments.

SYNTHESIS AND BIOLOGICAL EFFECTS OF SUBSTITUTED BENZOHYDROXY-AMIC ACIDS. Bart van't Riet, Howard L. Elford\*, and Galen L. Wampler\*, Dept. of Pharm. Chem., Biochem., and Div. of Medical Oncology, Med. Col. of Va., Richmond, Virginia, 23298.

Antitumor activity of certain substituted benzohydroxyamic acids (BHA) led to the synthesis of a number of new poly-substituted BHA's for studies of structure-activity relationships. Preparation of polyhydroxy BHA's cannot be done by the standard procedure of treating benzoate esters with an excess of hydroxylamine and base. Oxidation by traces of oxygen gives black tars. Our method to prevent this oxidation by addition of sodium sulfite to the aqueous solution, and by using closed containers succeeded in the preparation of 2 new trihydroxy BHA's and 3 dihydroxy BHA's. Also 3,4-diamino BHA was prepared. These and previously reported mono- and di-substituted BHA's were tested *in vitro* for inhibitory activity on isolated Novikoff hepatoma ribonucleotide reductase, and *in vivo* for ability to increase the life span of L1210 bearing mice. The most potent enzyme inhibitors were obtained by hydroxy substitutions at 2,3-, 3,4-, 2,3,4- and 3,4,5-positions. The high activity of 3,4-diamino BHA also indicated that adjoining substitutions enhance activity. The greatest activity *in vivo* was shown for 3,4-dihydroxy BHA, giving an increased life span of 103% after a daily dose of 600 mg/kg for 8 days. The best enzyme inhibitor, 2,3,4-trihydroxy BHA, gave an ILS = 30% at 100mg/kg-day, but larger doses caused toxic effects in mice. Aided by grant IN-105-C from the American Cancer Society.

THE EFFECTS OF SURFACTANTS ON THE ELECTRONIC TRANSITION SPECTRA OF BACTERIOCHLOROPHYLL IN PURPLE PHOTOSYNTHETIC BACTERIA. K.T. Rogers\*, J.J. Katz with S.J. Gamble. Argonne National Lab, Argonne, Ill. 60439

Disaggregation of bacteriochlorophyll molecules upon addition of surfactants to intact bacterial cells of *Rhodospseudomonas spheroides* and *Rhodospirillum rubrum* has been confirmed through visible absorption and electron paramagnetic resonance measurements. Preferential bleaching of P800 peaks in both bacterial species, along with the bleaching of P880 in *R. rubrum* and the appearance of a peak at 700nm is observed. The peak at 700nm has been shown to be monomeric bacteriochlorophyll. The actions of detergents are random and disruptive. It is thought that in the future, isolation of chromatophores without perturbation of the reaction center by the action of detergents would be desirable.



THE ANALYSIS OF SPECIFIC 2'-O-METHYLATION IN 5.8S rRNA. S. G. Ryan\* and T. O. Sitz, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

One of the low molecular weight ribosomal RNA species, 5.8S, in mammalian cells was found to contain two 2'-O-methylated positions in its sequence (J. Biol. Chem. (1975) 250, 8591). One of these methylated positions, UmG, was found to be a partial modification and varied in molar yield in RNA isolated from different normal and cancer tissues. The lowest levels of methylation were found in the cancer tissues (FEBS Letters (1975) 59, 83).

When different procedures for the digestion and separation of the oligonucleotides from 5.8S were compared with the same samples of RNA, variations were found in the absolute values for the molar yield of UmG. However the relative differences between tissues remained as earlier observed. Currently different methods for the isolation of 5.8S rRNA and its subsequent digestion and oligonucleotide fractionation are being investigated.

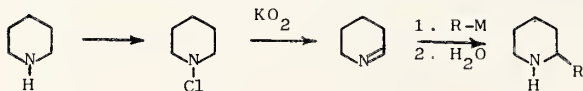
STUDIES ON THE NENITZESCU SYNTHESIS OF 5-HYDROXYINDOLES. I. Elizabeth K. Saunders\*, Jane L. Marcus\*, and James B. Patrick, John Baker Daffin Lab. of Chemistry, Mary Baldwin Coll., Staunton, Va. 24401

We describe an improved procedure for conducting the Nenitzescu synthesis in which the starting materials (a benzoquinone and a  $\beta$ -aminocrotonate ester) react at room temperature in nitromethane solution. Yields of 5-hydroxyindoles unsubstituted at 6 or 7 are only fair by this method, but for 6- or 7-substituted 5-hydroxyindoles the yields by the nitromethane procedure are comparable to the best previously reported. To elucidate the efficacy of nitromethane as a reaction medium we have studied the effect of  $pK_a$ , dielectric constant, oxidizing power of the solvent, and the solubility of the solvent in it.

We have also prepared numerous methyl esters in this series and find that the yields of 3-carbomethoxy-5-hydroxyindoles are considerably higher than the yields of the corresponding ethyl homologues. A mechanistic explanation is offered.

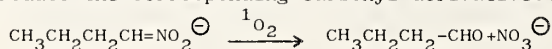
2-ALKYLATION OF AZACYCLOALKANES VIA N-CHLORAMINES. Frank E. Scully, Jr.\*, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

We have previously reported a mild, one-pot method of converting primary and secondary amines to imines by reaction of the corresponding N-chloramine. We now wish to report the extension of this reaction to cyclic systems and the alkylation *in situ* of the cyclic imine to form 2-alkylated products in moderate yields.



THE PHOTOOXIDATION OF NITRONATES, SYNTHONS FOR ACYL CARBANIONS. Frank E. Scully, Jr.\*, W. de Leeuw\*, and T. Hizer\*, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

Anions of nitroalkanes have been oxidized to carbonyl equivalents by several methods. Most of the methods previously employed, however, are limited by harsh conditions, poor yield, interference from other functional groups, or lack of generality. We have found that anions of primary and secondary nitroalkanes and  $\alpha$ -nitroesters react rapidly with singlet excited state oxygen to produce the corresponding carbonyl derivatives.



The different solvents and reaction conditions will be discussed. A mechanism involving a dioxetane-like intermediate will be proposed and defended. This reaction enhances the utility of nitronates as synthons for acyl carbanions.

STRUCTURES AND PROPERTIES, ESPECIALLY MAGNETIC INTERACTIONS, IN BINUCLEAR TRINUCLEAR, TETRANUCLEAR AND POLYMERIC TRANSITION METAL COMPLEXES. E. Sinn, Department of Chemistry, University of Virginia, Charlottesville, VA 22901

Magnetic and X-ray structural studies of various types of binuclear, trinuclear and polynuclear transition metal complexes indicate that structural factors govern the nature and strength of magnetic coupling between the metal atoms. Other factors (steric, electrostatic) are important mainly in an indirect way: they influence the structural factors and indeed they may be used to design certain complexes with specific desired structures. The bonding geometries of the metal and the bridging ligand atoms are the most important structural features governing magnetic behavior. In general, the magnetic coupling becomes more antiferromagnetic, or less ferromagnetic, as the principal coordination planes about the metal atoms come closer to being co-planar, as the geometry of the principal coordination plane approaches planarity, as the length of any out-of-plane bond increases, as the metal-bridging ligand-metal angle increases, and in the case of an oxygen bridge, as the geometry of the bridging atom approaches planarity. These factors all tend to improve the orbital overlap of the superexchange pathway. Other correlations previously reported of magnetism with various features, such as ring substituents, are not compatible with the results.

CHARACTERIZATION OF THE ADSORPTION OF WATER ON SILICA. Jean A. Skiles\* and J. P. Wightman, Chem. Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

The adsorption of water vapor on Min-U-Sil, a microcrystalline silica, has been studied in a constant volume system as a function of both isotherm temperature and pressure. The silica was examined with the scanning electron microscope. Surface areas of 4.4 and 2.6 m<sup>2</sup>g<sup>-1</sup> were determined with nitrogen and water, respectively. The high purity of the silica surface was established by use of the ESCA (electron spectroscopy for chemical analysis) technique. Water adsorption isotherms were determined at 30°, 40° and 50°C for silica outgassed at 100°C in vacuo for 2 hours. The isotherms were determined over a wide pressure range approaching saturation at each temperature. Isothermic heats of adsorption were calculated from the isotherm data as a function of surface coverage. The results suggest physisorption of water on a pure but partially hydrophobic silica surface. [Work supported under NASA Grant NSG-1389].

# THE REDUCTION AND OXIDATION OF MYOGLOBIN AND HEMOGLOBIN USING A SURFACE MODIFIED GOLD ELECTRODE.

Joyce F. Stargardt and Fred M. Hawkriged\*, Dept. of Chemistry, Va. Comm. Univ., Richmond, Va. 23284

Sperm whale myoglobin and beef hemoglobin exhibit quasi-reversible rates of heterogeneous reduction and oxidation at gold electrodes modified with 1,1'-dimethyl-4,4'-dipyridinium dichloride (methyl viologen, MV) in an optically transparent thin-layer electrochemical cell.

Spectrophotometric monitoring of electrochemical processes shows exhaustive reductive and oxidative electrolyses are reversible at the modified gold surface in five and fifteen minutes, respectively, for myoglobin. Hemoglobin requires twenty-five and twenty-five minutes in similar reductive and oxidative electrolyses. Myoglobin is highly irreversible in heterogeneous electron transfer in the absence of the surface modification.

The electroactivity of these biological molecules at a modified gold foil surface has also been monitored using cyclic voltammetry.

The analytical utility of this electroactivity imparted by the modified surface with heme proteins is currently being investigated in our laboratory.

DETERMINATION OF VITAMIN E BY HPLC, C.C. Tangney<sup>1</sup>, H. M. McNair<sup>2</sup>, J. A. Driskell<sup>1</sup>, <sup>1</sup>Dept. of Human Nutrition and Foods, <sup>2</sup>Dept. of Chemistry, V.P.I. & S.U., Blacksburg, Va. 24061

Vitamin E, a fat-soluble vitamin, is comprised of four major forms of tocopherol (α, β, γ, δ). Since the biological activity and abundance of these isomers in foods and biological materials vary considerably, a method was developed for the rapid determination of tocopherols by high-pressure liquid chromatography using a UV photometer. Both silica gel and reverse phase chemically bonded packings were evaluated. This method is easily adapted for analyses of food, plasma and tissues.

# OSHA REGULATIONS AND THE ACADEMIC CHEMISTRY LABORATORY.

Joseph A. Topich, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

OSHA regulations and their implications for academic chemistry laboratories will be examined. Items to be discussed will include: (a) general laboratory safety, (b) materials handling and storage, (c) personal protection, (d) fire protection, and (e) waste disposal.

THE ROLE OF THE ADENOSINE BINDING REGION IN THE COENZYME BINDING SITE OF LACTATE DEHYDROGENASE-X FROM MOUSE TESTES, Joyce L. Topping\* and James H. Yuan, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

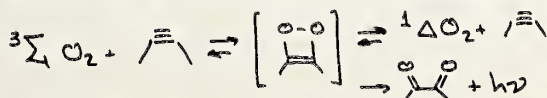
Lactate Dehydrogenase-X (LDH-X) from mouse testes has recently been purified to homogeneity by affinity chromatographic techniques (Mol. & Cell. Biochem., 18, 49-57, 1977). The properties of the coenzyme-binding site were studied with inhibitor analysis and multiple inhibition techniques. The results suggested that the binding of coenzyme molecule to the enzyme involves the interactions with several regions of coenzyme-binding site in the enzyme molecule.

It was found that n-alkylphosphates with various alkyl chain lengths were shown to inhibit the enzyme catalyzed reduction of NAD noncompetitively. However, the inhibition was observed to be competitive when studied in the presence of AMP. A derivative of n-alkyl-ADP was thus synthesized and studied as a possible inhibitor. The details of these studies will be presented.

# SPIN-FORBIDDEN REACTION PATHWAYS IN THE INTERACTION OF SINGLET AND TRIPLET MOLECULAR OXYGEN WITH ACETYLENE.

Carl Trindle, Chemistry Dept., Univ. of Virginia, Charlottesville, VA 22901.

According to symmetry arguments, the production of  $^1\Delta O_2$  from  $^1\Sigma O_2$  is feasible only if mediated by a long-lived collision complex. Experimentally the singlet  $O_2$  is a by product of the reaction



from which the chemiluminescent diketone is recovered. Symmetry arguments provide a detailed guide to the dissociation of dioxetene along spin-conservative or spin-forbidden pathways. The symmetry-based predictions are supported by MINDO/3 computations on the species shown and on alternative intermediates. The acetylene-catalyzed singlet-triplet interconversion may explain the high reactivity of triplet  $O_2$  in the presence of unsaturated molecules, including certain carcinogens.

# INDIRECT ATOMIC ABSORPTION METHOD FOR DETERMINATION OF HYDROGEN SULFIDE IN GASEOUS SAMPLES.

Billy T. Upchurch and Eric H. DeCarlo\*, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

The possibility of measuring hydrogen sulfide indirectly by monitoring the mercury evolved from the gas-solid reaction between hydrogen sulfide and mercury(I) chloride has been examined. The response to hydrogen sulfide was studied as a function of concentration and temperature. Possible interferences by water and sulfur compounds were examined. With the current system design hydrogen sulfide could be detected at concentrations as low as 15 parts-per-billion in air. Mercaptans were found to actively interfere with the conversion. Sulfur dioxide did not interfere even in very large concentrations. The time constant for the system was found to be small enough to permit monitoring on a real time basis.



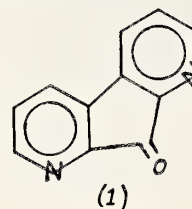
KINETIC ASSAY OF SERUM CREATINE KINASE ISOZYMES. M. Candace Whitehurst\* and James H. Yuan, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

Creatine kinase which exists in three isomeric forms is a dimer composed of either M (muscle) or B (brain) type subunits. The three creatine kinase isozymes differ in amino acid composition, catalytic constant, and electrical charge. It was found that brain contains only CK-BB isozyme and skeletal muscle has virtually only the CK-MM isozyme, while human myocardial tissue contains 80% CK-MM and 20% CK-MB (Clin. Chem., 22, 173, (1977), the presence of CK-MB isozyme in the serum is useful for diagnosing myocardial damage. Normal human serum contains only the CK-MM isozyme while the CK-MB isozyme appears in serum of patients with an acute myocardial infarction. A method for the determination of isozyme ratio of serum creatine kinase is thus developed. The method is based on the fact that isozymes often exhibit different catalytic activity and kinetic behaviors with various adenine nucleotide analogs. The details of the method will be presented.

(Supported by Grant from Tidewater Chapter of American Heart Association)

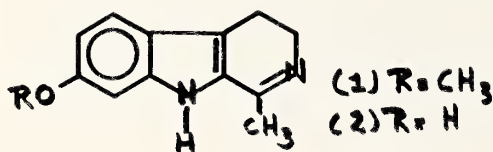
THE SYNTHESIS AND EVALUATION OF A NEW ANTITUBERCULAR AGENT. R. L. Williams, Dept. of Chemical Sciences, Old Dominion Univ., and Anderson J. Ward, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

In a recent study of the chemistry of 1,8-diazafluorenone (1) we have prepared a variety of carbonyl derivatives for evaluation for potential physiological activity. Several of these derivatives have exhibited significant antitubercular activity (MIC) when screened in a serial dilution method against *Mycobacterium tuberculosis* (strain H-37RV). The chemistry and potential development of these systems will be discussed.



ALKALOID POLYMERS. R. L. Williams and Gretchen Williams, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

Recent interest in the chemistry and biological activity of compounds related to the histamine releasing agent 48/40 have propted us to investigate the general polymerization of a variety of synthetic and natural phenolic and methoxy substituted ring systems. Of particular interest are the polymers synthesized from various harmala alkaloids such as harmaline (1) and harmalol (2). The general synthetic procedure for the polymerization together with the characterization of these new alkaloid polymers will be discussed.



BIOCHEMICAL CHARACTERIZATION OF MALIC ENZYME AND GLUCOSE-6-PHOSPHATE DEHYDROGENASE FROM MOUSE TISSUES. James H. Yuan, Dept. of Chem. Sci., Old Dominion University, Norfolk, Va. 23508, and C. Y. Lee, Lab. of Environmental Mutagenesis, Natl. Inst. of Environmental Health Sciences, Research Triangle Park, N. C. 27709

NADP<sup>+</sup>-dependent cytoplasmic malic enzyme and glucose-6-phosphate dehydrogenase were purified by affinity chromatographic technique from kidneys and testes of two inbred strains DBA/2J and C57BL/6 mice. The biochemical properties including molecular weight, amino acid composition, kinetic constants, thermal stability and chemical denaturation were compared.

Malic enzyme from both strains of mice were found to be a tetramer with a molecular weight of 270,000, and were indistinguishable with respect to their biochemical properties.

Glucose-6-phosphate dehydrogenase from both strains of mice were found to exist as tetramer with a molecular weight of 220,000. The purified enzymes from kidneys and testes were also observed to have high specificity for glucose-6-phosphate, and exhibit no activity with NAD<sup>+</sup> as coenzyme. The enzymes from both strains were shown to be identical with respect to their structural and biochemical properties.

## Section of Education

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

**MODELS OF RESEARCH AND EVALUATION IN SCIENCE EDUCATION.** Michael L. Bentley, Graduate Instructor, Department of Curriculum and Instruction, School of Education, Univ. of Va., Charlottesville, VA 22903

Most research in science education has operated under a paradigm borrowed from agricultural botany through the route of educational psychology. Such a model has implications for the results of the study. Other research paradigms exist but have rarely been used by science education researchers. These are derived from the social sciences and, in the natural sciences, from the young science of ethology. These models also have implications for research results. An example of the use of alternate methodologies is the National Science Foundations recently completed Precollege Science Education Status Studies which used case studies as an important component. Another example is the Ford Foundation-University of Virginia study of preactive teacher planning. These studies illustrate the usefulness of this type of research paradigm in science education.

**THE SCIENCE MUSEUM OF VIRGINIA: THE ROAD TO DISCOVERY.** D. W. Cocks, Science Department, The Collegiate Schools, Richmond, Virginia. 23229

Virginia has a new dimension in science education. In 1971, the General Assembly of Virginia created the state agency---the Science Museum of Virginia. From its inception, the major thrust has been to provide a whole new field of self-motivation experiences in learning through exhibits that appeal to the senses, emotions, and intellect.

The Science Museum of Virginia is converting a 20,000 square-foot railroad station into a center for inquiry and discovery. Here people can satisfy their curiosity about branches of science that are having more and more impact on daily life. In addition to the Discovery Room in Richmond, the museum is committed to disseminating information to peoples throughout the state. Transcience II, a mobile unit, is making plans to visit many counties throughout the Commonwealth.

The history of its beginning, the present facilities, and plans for the future will be shown in a slide/tape presentation.

**GETTING KEYED-UP WITH CALCULATORS.** Virginia C. Ellett, Mathematics and Science Center, Glen Allen, VA 23060

Calculators exist in the "real world"; therefore science teachers cannot and should not ignore them.

In the science classroom, calculators give students the opportunity of successfully solving problems that they might not consider attempting due to lengthy computations. This leaves the students with more time to deal with facts and concepts, and to do inductive and deductive reasoning. Many of the interesting problems that can now be easily solved relate to real life experiences.

Calculators lessen the need for memorization and give immediate feedback. They also encourage speed and accuracy and make computations much less frustrating for low achievers.

Opportunity to participate in hands-on activities solving true-to-life energy problems.

**MAKING WAVES WITH MARINE SCIENCE UNITS IN ELEMENTARY CLASSES.** E. Fisher\*, Virginia Institute of Marine Science, Gloucester Point, Virginia 23062

The importance of the marine environment to man's survival is apparent. In order to instill a sense of responsibility and sensitivity for the marine ecosystem, education must begin at the primary school level.

At the Virginia Institute of Marine Science we are presently writing and field testing a curriculum in marine education in the Gloucester County schools for grades kindergarten through three. A unit consists of eight lesson plans including detailed directions and background information for the classroom teacher. The curriculum is designed to be easily integrated into existing class studies and includes activities in language arts, drama, and art. Using a hands-on, open-ended inquiry approach the unit emphasizes processes of science, content, and attitude development.



EXPERIENCES RELATED TO OCEANIC ATTITUDES AND KNOWLEDGE OF TENTH GRADE STUDENTS IN VIRGINIA. Rosanne W. Fortner. Coll. of Education, Va. Polytechnic Inst., Blacksburg, Va. 24061

A study was designed to identify which of an individual's marine-related experiences are most closely related to his level of oceanic knowledge and his attitudes toward the ocean. The Survey of Oceanic Attitudes and Knowledge (SOAK) was administered to a total of 787 tenth grade students in thirty high schools in Virginia. Data analyses indicated that students from both coastal and inland schools held positive attitudes toward the ocean even though they showed little knowledge regarding ocean-related topics. The relative importance of various experiences, as expressed by the students, was compiled into a scale of perceived influence for each geographic area. Television and movies were rated "most influential" for both areas, with books and newspapers rated lowest. Comparisons of highly ranked experiences with knowledge and attitude scores indicated that what students perceived as "most influential" was not necessarily the type of experience most closely related to their oceanic knowledge and attitudes.

Through this study baseline data on ocean awareness have been obtained, and the relationship of oceanic experiences to that awareness has been explored. For marine educators the study has implications concerning the needs of the population with regard to knowledge and the methods by which those needs may be met.

IDENTIFICATION AND EVALUATION OF SCIENCE COMPETENCIES (PROJECT C-BASS). H.B. Lantz, Jr., Orange County Public Schools, Orange, Va. 22960

The identification of competencies (life skills), the writing of performance indicators for those identified competencies, and the design of evaluative instruments to assess student progress toward the mastery of these competencies are all part of a big movement in education today—The Minimum Competency Movement. Although a number of states and hundreds of local school districts have initiated efforts for identifying and evaluating communication and computational skills, few school districts have addressed themselves to the task of designing competency based science programs and the evaluation of such programs.

Through Project C-BASS (Competency Based Approach for Survival Skills), local school officials, parents, and students have begun to identify those minimal science competencies needed for successful functioning in society today and to design instructional programs and evaluative methods to implement those identified science competencies. Locally, nineteen minimal competencies have been identified that contribute to four basic science goals—attitude, skills, rational thinking, and knowledge.

THE SPAWNING AND HATCHING OF THE VIRGINIA MARINE EDUCATION ASSOCIATION. J. A. Lanier. Marine Education Section, Va. Inst. of Marine Science, Gloucester Point, Va. 23062.

In November of 1977 over 130 educators met at VIMS for a two-day session on "What's Happening in Marine Education in Virginia?" It was decided that a similar meeting annually would be useful as a part of a Marine Education Association. A committee formed at that time has since met and decided on a full-scale organizational meeting at VIMS on 22 and 23 September 1978. Md. and Va. educators have been invited to join with Va. in a regional association.

ENERGY CONSERVATION PROGRAM FOR HOMEOWNERS. Wayne P. Smith\*, Director, Fairfax County Department of Extension and Continuing Education, Fairfax, VA 22030

Energy demand continues to grow, despite the rapid escalation of energy costs. The potential for reducing costs through energy conservation is greater than the potential for reducing costs in any other way available to the homeowner. Therefore, an educational "How To" program attempted to persuade the homeowner to look upon energy conservation as an investment opportunity rather than a necessary evil.

ENVIRONMENTAL EDUCATION: THE MIDDLE SCHOOL COMPONENT. Janice O. Wax, Orange County Public Schools, Box 349, Orange, Virginia 22960.

Since the National Validation of Project COMSEP (Comprehensive School Environmental Program) through ESEA Title IV-C, the middle school component has evidenced the greatest growth in this K-12 program. Curriculum development efforts have been implemented in all three of the learning modalities. Cognitive emphasis includes studies on ecosystems, economics, and technology. Psychomotor work includes basic skill development in experimentation and measurement, and affective development involves values clarification through environmental ethics and decisions. As an outgrowth of this curriculum development, an ecology club has been started. Club activities include day trips to areas of local environmental concern, 2 weekend trips to coastal and mountain settings, and extensive plant and animal work in an environmental interpretation center located in a courtyard of the school. Plans are underway to revise instructional and attitudinal instruments that were developed several years ago and to formulate a basic skills instrument in an effort to evaluate the efforts that have been made. This work will be done in conjunction with the Dept. of Research and Methodology at the University of Virginia.

STATUS OF ELEMENTARY SCIENCE IN THE COMMONWEALTH OF VIRGINIA. E. P. White\*, Div. of Sciences & Elementary Administration, Va. Dept. of Education, P. O. Box 60, Richmond, Va. 23216

A report on the current status of elementary science in the public schools of Virginia. Utilized a variety of numerical data and observations made from visitations to over 90 school divisions during the past three years. Data presented include: item analysis of 1976+1977 SRA (4+6th grade) science scores; relationship of student achievement to other variables; type and percentage adoption of NSF and commercially developed elementary science programs; and identification of possible reasons why implementation has been limited.

Numerical data analysis was interspersed with observational data from on-site visitations including analysis of future needs and recommendations for possible research studies. The major objectives of the Science Education Services, in regards to elementary science for the next three years, was related to these data.

AN ASSESSMENT OF THE PERFORMANCE OF VIRGINIA HIGH SCHOOL STUDENTS ON SELECTED BASIC SKILLS. F. D. Kizer, Dillard Haley, Va. Dept. of Education, Richmond, Va. 23216, and Alvin Pettus\*, VPI and SU, Blacksburg, Va. 24061.

Eight basic science skills were selected and defined in behavioral terms. The Test of Science Processes was selected as the instrument to measure proficiency in the selected skills.

The instrument was administered to 19 Y.C.C. Camps (N=505) during the period July 15 - August 15, 1977. A short questionnaire accompanied the test to determine characteristics of the sample, (age, grade, sex, science courses completed, career interests, high school attended).

Multiple regression analysis was used to determine the relationship between the test scores and selected variables. Means were computed for each basic skill by categories.

Variations in the levels of proficiency among the eight skills have been determined. Further analysis indicates several variables which are predictors of test scores.

VIRGINIA HIGH SCHOOL PHYSICS TEACHER SURVEY. H. K. Moore and J. R. Gordon. Dept. of Physics, James Madison University, Harrisonburg, Va. 22801

A survey taken during the 1975-76 school year was conducted with a 101 item questionnaire sent out to all high school physics teachers in Virginia.

The purpose of the survey was to look at each of the four following broad areas pertinent to high school physics in the state: (i) numbers of students taking physics; (ii) nature of schools offering physics; (iii) nature of the physics course as determined from facilities, content and lab work; (iv) teacher characteristics as determined from experience and training.

There is no clear trend shown by the data that school size alone is an indicator of strength of the physics program (as measured by the proportion of students taking physics). Teacher characteristics, in terms of years experience and academic course background is somewhat of an indicator of course type.

AQUA RIVER VALLEY--CURRICULUM MATERIALS ON WATER RESOURCES FOR THE SECONDARY SCHOOLS. Larry H. White, Dept. of Chemistry, Eastern Mennonite College, Harrisonburg, VA 22801 and William R. Walker, Director, VA Water Resources Research Center, VPI & SU, Blacksburg, VA 24060

The impetus for this project grew out of a perceived need by the Water Center and the College of Education at VPI & SU. The materials are designed to stimulate interest and to give direction to the study of water resource problems in the student's local community, and to suggest some methods useful for solving these problems.

The Aqua River Valley is a hypothetical area with a variety of water resource problems which is used as a means to introduce students to these real-world problems. A variety of formats are used for the various units in the course to stimulate interest. Activities with each unit are designed to get the students into their own area to locate and study water resource problems. After completing the final unit, which involves developing a plan to solve Aqua River Valley's water resource problems, the students should be able to understand what will be needed to solve the problems in their own community.

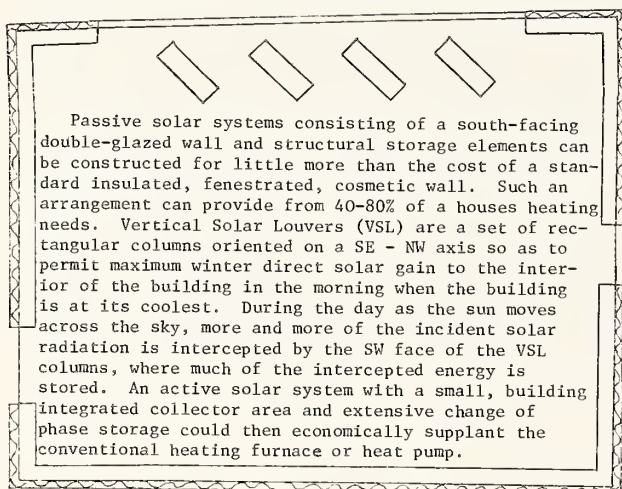
The next step in the project will involve a pilot study in selected areas of the state to assess student interest and reaction to the materials and to assess the effectiveness of the materials.



# Section of Engineering

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

VERTICAL SOLAR LOUVERS AND HYBRID (ACTIVE-PASSIVE) SYSTEMS FOR LOW-COST 100% SOLAR HEATING OF BUILDINGS. James Bier  
Dept. of Chemistry, Ferrum College, Ferrum, Va. 24088



OPPORTUNITIES FOR ENGINEERING RESEARCH IN COAL. W. R. Hibbard, Jr., University Distinguished Professor of Engineering and Director of the Virginia Center for Coal and Energy Research, VPI&SU, Blacksburg, Va., 24061.

The most pressing needs for new coal technology is related to methods for burning coal without adversely affecting the environment. Fluidized bed combustion offers a unique solution, but engineering research is required to scale up the process for utility plants and scaling it down for residential, commercial, and farm buildings. Processes such as flotation and solvent refining, which clean the coal require engineering research but may also benefit from fluidized bed combustion.

In the field of coal mining the most important needs are related to the engineering development of equipment to reclaim as well as uncover surface coal mines and in deep mines, equipment which is remote controlled and systems oriented to improve productivity and safety. Other important areas are related to roof control and atmosphere monitoring for dust, methane and oxygen.

NONUNIFORM FLOW EFFECTS ON THE LI AND GEIGER STAGNATION-POINT SOLUTION FOR A BLUNT BODY IN A HYPERSONIC FLOW. William P. Harrison, Jr., Div. of Engineering Fundamentals, VPI&SU, Blacksburg, Va. 24061

The Li and Geiger stagnation-point solution for a blunt body in a uniform hypersonic flow is modified by replacing the uniform freestream boundary condition at the shock wave with a nonuniform wake-like flow symmetrical about the stagnation streamline. Analytical expressions are developed for important flow quantities such as shock wave standoff distance, velocity components, pressure coefficient, and velocity gradient at the stagnation point for both two-dimensional and axisymmetric flows. The results show that the effects of a nonuniform freestream can become quite significant, particularly at high Mach numbers, producing both higher heating rates and higher surface pressures than occur in the uniform flow case.

AN ANALYTIC MODEL TO DESCRIBE THE SHAPE OF SEPARATED FLOW REGIONS UPSTREAM OF FINITE SPAN PROTUBERANCES IN TURBULENT HYPERSONIC FLOW. R. D. Kirchner, Inst. for Hypersonic Studies, Inc., 7602 Cornwall Road, Richmond, Va. 23229

A simple analytic technique was developed which can predict the shape of separated flow regions upstream of finite span protuberances in turbulent hypersonic flows. The technique relies upon certain simplifying assumptions in which a reverse flow region, just above a surface in turbulent hypersonic flow, can be assumed to be represented by a two-dimensional inviscid incompressible flow with a source distribution existing across the span of a protuberance. The source distribution is superimposed upon a uniform free stream; and the resulting stream function relationship is solved for as a function of the source strength, which is determined from boundary conditions at the edge of the separated flow region. A thorough investigation was conducted in which predicted results, using the technique, were compared directly with oil flow studies for over twenty-five cases. Excellent results were obtained for cases with separated flow regions produced by circular cylinders, steps, ramps, and shock wave/boundary layer interactions.

THE ENGINEER, UNPAID ASSET ACQUISITIONS, AND INDENTURED SERVANTS. Howard R. Johnson\*, New Products Specialist, 314 N. Main St., Blacksburg, Va. 24060.

Endeavoring to define some of the far flung responsibilities of engineers for products and systems, the author has drawn upon current case histories to show discrepancies in the hiring of engineers. A major discriminating factor is the assignment of intellectual property without any recourse as a condition of employment. As the U.S. Code sees only labor and management, and there has never been a deviation filed for disfranchised labor. It appears that a substantial legal gap exists. The assignment of intellectual property involves not only the property but secrecy concerning it and may block employment in the engineer's area of expertise for at least two years.

THE ENERGY AUDIT - A FIRST STEP TO ENERGY CONSERVATION. R.R. SOMERS II\* and L.S. Fletcher, Dept. of Mechanical and Aerospace Engineering, Univ. of Va., Charlottesville, Va. 22901

With the advent of energy shortages and rising energy costs, many municipalities have initiated conservation programs aimed at reducing energy expenditures. The energy analyst must determine what information is necessary to compute the energy usage, cost, and requirements of the facilities under study.

A research group from the Mechanical and Aerospace Engineering Department of the University of Virginia recently completed a survey of the energy consumption in the City of Charlottesville, Virginia for the 1972-1977 fiscal years. This experience has been helpful in indicating the information needed for a successful energy audit, including energy costs and usage, building structural characteristics, and climatological data. Sources of this information include the budget of the facilities being analyzed, utility company records, architectural drawings, and weather information. Sufficient data must be available to permit the compilation of energy use and cost per square foot and/or degree-day to facilitate comparisons with current and future performance standards. A thorough assessment of past energy use is needed to pin-point specific areas of excessive energy usage.

THERMAL ANALYSIS OF SEASONAL STORAGE ENERGY SYSTEMS, J.T. Beard and L.M. Fafarman\*, Dept. of Mechanical and Aerospace Engineering, Univ. of Va., Charlottesville, Va. 22901

Seasonal solar energy storage systems have been proposed as an economical design concept for application to space heating. The primary advantage of seasonal systems is that solar energy is collected whenever it is available (including the summer) and is stored in order to be able to meet the heating demand in the colder months. Seasonal storage energy heating systems would typically have considerably larger storage volumes and smaller collector areas than the traditional solar heating systems which have been developed during the last twenty years. Seasonal storage systems would have an advantage relative to traditional systems in that they could be sized to provide for all of the seasons' heating needs without the requirement of an auxiliary energy source.

This paper discusses the geographical and climatic factors that tend to favor seasonal storage systems. Analytical heat transfer expressions are presented to illustrate the transient features of solar energy collected, storage temperatures, energy demands, and energy losses. Energy is considered to be stored as sensible heat using both unprepared ground and water as the storage medium. The insulating features of unprepared ground are described. Various design criteria for seasonal solar energy storage systems are presented along with examples.

VARIATION OF INTERNAL L-METHIONINE CONTENT IN CEPHALOSPORIUM ACREMONIUM. L.A. Coogan\* and S.W. Drew, Chemical Engineering Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Experiments in our lab indicate that the internal methionine pool levels do not remain constant in Cephalosporium acremonium CW-19 cultures during antibiotic fermentation. While cells grown in either a methionine or a sulfate supplemented defined medium show comparable pool sizes at the end of the fermentation period, there are differences during the course of the fermentation. Cells growing in medium to which DL-methionine has been added show a peak internal L-methionine concentration after two days; sulfate grown cells reach a lower peak at a later time.

SEM<sup>1</sup> AND ESCA<sup>2</sup> ANALYSIS OF POLYMERS AND COPOLYMERS. T. F. Davidson\*, D. W. Dwight\*, J. E. McGrath\*, R. Viswanathan\*, and A. J. Wnuk\*, Dept. of Chem., Va. Polytechnic Inst., Blacksburg, VA 24060.

The overall goal is to develop an understanding of structure-property relationships in high-performance engineering thermoplastic copolymer systems. Poly(arylsulfone-aryl carbonate) and poly(dimethylsiloxane-arylcarbonate) multiblocks can exhibit microphase separation as a function of block size and composition that are important to the macroscopic properties of interest. SEM and ESCA have resolved features of the domains in our systems. SEM fractography provided identification of domain distribution and showed that the harder blocks dominated the micromechanisms of deformation and failure. Preferential segregation of the low-surface-energy block was revealed by ESCA determination of the stoichiometry in the top nm of the specimens.

<sup>1</sup> SEM is an acronym for Scanning Electron Microscopy.

<sup>2</sup> ESCA is an acronym for Electron Spectroscopy for Chemical Analysis.

(Aided by NSF grant, polymer program DMR 76-11963)

MEASUREMENT OF STRAIN IN THIN MEMBRANES USING MOIRE' INTERFEROMETRY. J. G. Dixon\*, R. D. Flack\*, J. G. Thacker\*, Dept. of Mechanical and Aerospace Engineering, Univ. of Va., Charlottesville, Va. 22901

An optical method was utilized to measure strain in thin membranes, some of which contained stress concentrators. The method used is briefly described as follows. A thin photographic emulsion was sprayed on the membrane. Next a set of parallel evenly spaced fringes was focused on the unstressed membrane and the emulsion was exposed. After stretching the membrane a second set of fringes was printed on the emulsion. The two fringe sets interfered and formed an interferogram. The resulting patterns were representative of Moire' interferometry and were permanently recorded via a camera. The Moire' patterns were then used to determine strain values throughout the thin membranes.

Preliminary tests involving a thin membrane placed under uniaxial tension, with no stress concentrator, demonstrated the technique predicts strain within an error of 5%. Results for a thin membrane containing a stress concentrator will be presented. (Sponsored by the NIH Biomedical Sciences Support Program under the Univ. of Va. BRS Subgrant 5-22521).



COMPARISON OF LIGNIN BIOTRANSFORMATION CAPACITIES OF LIGNIN-DEGRADING FUNGI AND THE EFFECT OF CARBOHYDRATES ON LIGNIN METABOLISM. K.L. Kadam\* and S.W. Drew. Chemical Engineering Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Three well-characterized white-rot fungi, which have been the object of lignin biotransformation studies by other researchers, and four fungi isolated in our laboratory were compared for their ability to transform lignin.  $^{14}\text{C}$ -labeled kraft lignin was used as a substrate and  $^{14}\text{CO}_2$  liberated by organisms was used as a criterion for lignolytic activity. The effects of several carbohydrates as cosubstrates on lignin metabolism were studied. Less accessible carbohydrates like microcrystalline cellulose lead to higher lignolytic activities than did easily metabolized carbohydrates like cellobiose.

According to our data *Aspergillus sp.*, a fungus isolated in our laboratory, was most efficient in  $^{14}\text{CO}_2$  evolution. *Aspergillus sp.* also decolorized the brown lignin medium. This observation may have important applications in the treatment of effluents from the pulp and paper industry. In a detailed study, *Aspergillus sp.* produced higher amounts of  $^{14}\text{CO}_2$  and also exhibited higher ratios of  $^{14}\text{CO}_2/\text{CO}_2$  from carbohydrate than did *C. versicolor*.

MATHEMATICAL MODEL TO STUDY THE FLUSHING CHARACTERISTICS FOR POLLUTANT IN THE LAFAYETTE RIVER, NORFOLK, VA. J. D. Mayhew\* and C. Y. Kuo. Dept. of Civil Engr., Old Dominion Univ., Norfolk, Va. 23508

Following PL 92-500, an understanding of flushing characteristics of estuaries in urban areas is useful for coastal resources management and pollution control. An existing one dimensional, LaGrangian network model was modified and used to simulate dispersion and hence calculate the flushing time for a conservative pollutant in the Lafayette River, an estuary in Norfolk. Using available field data, the model was calibrated and verified against tide stages, mean velocities, and dye distribution. After an independent slug release of Rhodamine WT dye, maximum dye concentrations were monitored for a period of approximately thirty days. Comparison of the time variation of the maximum dye concentration with the mathematical model showed excellent agreement. The flushing time for this study was defined as the time required for 50% reduction in maximum dye concentration or total dye mass remaining in the estuary.

THE TERRASET SCHOOL - A RESEARCH AND EDUCATIONAL LABORATORY IN NORTHERN VIRGINIA. D. L. Michelsen, Engineering Extension, Va. Polytechnic Inst. and State Univ., Dulles, R. H. Pusey, Technical Resources, Extension Division, Va. Polytechnic Inst. and State Univ., Blacksburg, Va., T. Martin, Fairfax County Public School System, Fairfax, Va.

The Terraset Elementary School located in Reston, Va. has an open floor plan with four circular learning areas and considerable window viewing area for a buried school. Aside from winning architectural acclaim, it has a complete energy conservation reclaim system and an electronically controlled solar assist mounted high over the school entrance courtyard. The Terraset Foundation has been founded (1) to provide documentation of the school's performance, (2) to conduct tours through the solar equipped school, (3) to develop a research program for continued improvement of the Fairfax County School and (4) to initiate short courses for technical and non-technical training using the school as a laboratory. Virginia Tech's involvement has centered on proving the research, engineering and continuing education expertise as an active participant in the Terraset Foundation.

THERMAL CONTACT CONDUCTANCE OF FIN-TUBE SOLAR COLLECTOR MATERIALS. J. W. Miller\*, and L. S. Fletcher. Department of Mechanical and Aerospace Engineering, University of Virginia, Charlottesville, Va. 22901

Interest in solar energy has increased significantly during the past few years, with a proportional increase in the use of solar collectors. Many of these solar collectors involve a fin and tube configuration for heating a fluid, with an aluminum fin assembly clamped or pressed onto a copper tube. The aluminum fin absorbs the energy, transferring it as heat to the working fluid flowing through the copper tube. The thermal contact conductance or resistance to heat flow at the aluminum-copper interface directly effects the overall performance of the solar collector. In order to evaluate the various parameters effecting the thermal contact conductance, an experimental investigation of the heat transfer characteristics of an aluminum-copper interface was conducted. Interface load pressure and mean junction temperature were varied over the range of conditions anticipated for solar collector assemblies. Aluminum and copper surface finishes also were measured to ascertain their effect on the thermal contact conductance. Results of the investigation indicate that both increased temperature and/or increased load pressure improve the heat transfer characteristic of aluminum copper interfaces.

SIMULATION OF EROSION AND SEDIMENTATION BY A FINITE ELEMENT MODEL OF OVERLAND AND CHANNEL FLOW. E. B. Ross\*, V. O. Shanholitz, Dept. of Agricultural Engineering, and D. N. Contractor\*, Dept. of Civil Engineering, VPI&SU, Blacksburg, VA 24061.

A finite element numerical model was developed to route flood flows in a watershed, given soils, landuse, topographic descriptors and rainfall as input. The model represents a distributed parameter approach to watershed modeling and its spatial responsiveness allows the effects of localized and areawide landuse changes on the hydrologic response of a watershed to be determined.

These features allow for a ready application of the model to the simulation of erosion and sediment transport. The following approaches will be taken concerning the routing of sediment: (a) sediment yield to the channels will be predicted by an empirical relationship that defines yield from homogeneous upland areas and (b) channel sediment routing will be performed utilizing fundamental sedimentation mechanics.

A conceptual framework will be provided whereby the integrated effects of various landuse activities on sediment yield and any control measures to be implemented on a watershed can be evaluated.

FRACTURE SURFACE STUDIES OF SINGLE LAP JOINTS BONDED WITH A VISCOELASTIC ADHESIVE. E. Sancaktar\*, Dept. of Engineering Science and Mechanics, H. F. Brinson, Department of Engineering Science and Mechanics and D. W. Dwight\*, Dept. of Materials Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Technological applications of polymeric adhesives and composites continue to advance 25% per year. Engineering design requirements for these materials include prediction of time-dependent properties as well as effects of process variations. Scanning Electron Microscopy (SEM) on fracture surfaces of bulk "Metlbond 1113" (100% epoxy on carrier cloth) showed uniform, ductile fracture. When bonded in aluminum lap shear joints, a wide dispersion of flaws, plastic deformations and brittle fractures accompany the scatter in strength vs. rate data. Surface roughness determined with a Talysurf Profilometer was used to approximate true fracture areas. These fractographic data, combined with viscoelastic characterization of the bulk will be interpreted in terms of a unified, energy-balance theory of failure.

# Section of Environmental Sciences

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

SEA TRUTH CORRECTION PROCEDURE FOR REMOTE SENSOR OBSERVATIONS. Carvel Blair, Dept. of Mathematics & Computing Sciences and Inst. of Oceanography, Old Dominion University, Norfolk, VA 23508.

Sea truth corresponding to remote sensor observation of a particular parameter cannot always be obtained at the moment of remote sensing. Particularly in tidal waters, a time lapse between remote and in-situ measurements can cause a significant difference in respective values. One correction procedure averages sea truth measured at equal time intervals before and after remote observation to represent the value of the parameter actually existing at the instant of remote measurement. An alternative is to ignore the time difference on the assumption that negligible change occurred during the interval between remote and in-situ observation.

Errors resulting from both procedures were determined for sinusoidal, sawtooth, and spike models as well as field measurements of current velocity, suspended sediment concentration, and light attenuation coefficient. Results indicate that the averaging procedure produces significantly greater accuracy if the time-early/time-late interval is considerably less than the period of parameter fluctuation. If the interval approximates the fluctuation period, neither averaging nor ignoring the time difference yields a good standard for testing remote data. One should therefore understand the temporal behavior of the variables being measured before designing a sea truth collection program.

PROCEDURES UTILIZED FOR OBTAINING DIRECT AND REMOTE ATMOSPHERIC CARBON MONOXIDE MEASUREMENTS OVER THE LOWER LAKE MICHIGAN BASIN IN AUGUST OF 1976. J. C. Casas, E. Condon\*, and S. A. Campbell\*. Research Foundation, Old Dominion Univ., Norfolk, Va. 23508

In order to establish the applicability of a gas filter correlation radiometer, CFCR, to remote carbon monoxide, CO, measurements on a regional and worldwide basis, Old Dominion Univ. has been engaged in the development of accurate and cost effective techniques for inversion of CFCR CO data and in the development of an independent gas chromatographic technique for measuring CO. This independent method is used to verify the results and the associated inversion method obtained from the CFCR. The CFCR measurements and independent chromatographic measurements agree within 18 percent for data taken over the Lower Lake Michigan Basin in August of 1976. (Aided by NASA grants NSC 1394 and 1395.)

NON-POINT SOURCE POLLUTION IN THE CHINCOTEAGUE BASIN.

C. F. Cerco\* and C. S. Fang\*. Dept. of Physical Oceanography and Hydraulics, Va. Inst. of Marine Science, Gloucester Point, Va. 23062

Based on field data collected from ten sample sites encompassing seven land uses, the U. S. Army Corps of Engineers' STORM model has been calibrated and applied to the watershed of the Chincoteague Bay System located on the eastern shores of Delaware, Maryland, and Virginia. Current and projected year 2000 non-point source pollution loads have been calculated and current loads have been compared with point source discharges and storm-generated marsh nutrient exports. Point sources are responsible for larger quantities of ammonia and phosphorous while non-point sources contribute greater amounts of nitrate and coliforms. Rough equivalence is noted in the contributions of organic nitrogen and BOD<sub>5</sub>. A single storm on the local marshes, however, can produce nutrient export of the same order of magnitude as the monthly average point or non-point source loads from the remainder of the basin.

MATHEMATICAL SIMULATION OF FLOW CIRCULATION AND BIOGEO-CHEMICAL WATER QUALITY. H. S. Chen\*. Dept. of Physical Oceanography and Hydraulics, Va. Inst. of Marine Science, Gloucester Point, Va. 23062

A two-dimensional real-time mathematical model, which combines hydrodynamic and biogeochemical water quality systems, is employed to predict flow circulation, water elevation and water quality response in a natural water body such as river, estuary or sea.

The hydrodynamic system is based on the depth integrated continuity and momentum equations.

The biogeochemical system is based on the depth integrated conservation of mass equation. The system consists of ten coupled sub-systems corresponding to ten constituents; namely, salinity, coliform bacteria, phytoplankton (chlorophyll "a"), organic nitrogen, ammonia nitrogen, nitrite-nitrate nitrogen, organic phosphorus, inorganic phosphorus, carbonaceous biochemical oxygen demand and dissolved oxygen deficit. Where these sub-systems are coupled, either Michaelis-Menton or first order reaction kinetic in reaction processes is assumed.

The model uses Galerkin's weighted residual finite element numerical scheme, and is applied to the Hampton Roads 208 study.



ANALYSIS OF THE 1977 REGIONAL OZONE STUDY. G. E. Copeland and E. W. Barry\*. Dept. of Physics & Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

Detailed analysis of the hourly ozone concentrations, wind directions and speeds recorded at twelve specially designed ambient air pollution stations located in eastern North Carolina and Virginia is presented. During the 91-day study (2184 hours of data), several of the stations exceeded the National Primary Air Quality Standard for oxidants (80ppbv for 1 hour once a year) more than 20% of the time. Analysis includes wind roses,  $O_3$  dose roses, and  $O_3 > 80ppbv$  roses constructed from the local as well as the 2000ft. winds as strong influence of sea breezes on local  $[O_3]$  is evident in the maritime stations. Analysis using 2000ft. winds indicates real differences between rural and urban stations, with both having their largest occurrence of high  $[O_3]$  with westerly through northerly 2000ft. flow.

COLLECTION AND ANALYSIS OF OZONE DATA FROM THE SOUTHEASTERN VIRGINIA URBAN PLUME. G. L. Gregory\*, H. S. Wagner\*, J. J. Buglia\*. NASA, Langley Research Center, Hampton, Va. 23665

In preparation for programs to check out remote sensors now under development, an airborne sampling program was conducted in August 1977 using in situ instruments to determine if the urban plume of Southeastern Virginia would be a suitable target of opportunity. The airborne in situ instruments measuring  $O_3$ ,  $NO/NO_x$ ,  $CO$ ,  $CH_4$  and particulates were used to define the Southeastern Virginia Urban Plume. Verification of the existence and definition of the characteristics of this urban plume are a prerequisite to experiments using the maturing NASA remote sensing capability for  $CO$ ,  $CH_4$ ,  $O_3$ ,  $SO_2$ , and particulates. This airborne program was coordinated with a program of the Virginia State Air Pollution Control Board to evaluate the ground level ozone concentrations in air masses as they are transported through this region. The twelve ground stations operated by Virginia State Air Pollution Control Board provided data on the surface  $O_3$  concentrations during the airborne program. The mixing layer height was determined from measurements from the NASA Langley lidar and from radiosonde releases from the Norfolk airport and the Wallops Flight Center.

Plans are currently underway to design similar experiments for summer 1978 and 1979 with emphasis on: (1) the application of NASA remote  $O_3$  detectors to identification of urban  $O_3$  plumes, (2) more detailed measurements of  $O_3$  generation processes, and (3) the fate of  $O_3$  during the night.

A PHYTOPLANKTON ECOSYSTEM MODEL FOR THE YORK RIVER. P. V. Hyer\*. Dept. of Physical Oceanography & Hydraulics, Va. Inst. of Marine Science, Gloucester Point, Va. 23062

A ten-component phytoplankton ecosystem model was constructed, calibrated and verified for the York River. The components were: salinity, fecal coliform count, carbonaceous BOD, dissolved oxygen, chlorophyll concentration, organic nitrogen, ammonia, nitrate plus nitrite, organic phosphorous and inorganic phosphorus. The salinity and coliform sub-models were independent of the other components but the other eight components were interconnected, with nitrogen and phosphorus recycled through living phytoplankton, represented in the model by chlorophyll concentration. The effects of both decay of BOD and oxidation of ammonia were included in the oxygen balance equation.

The model had two layers and three lateral segments to reflect the great depth and width of the York River. It is observed that deep-lying waters between Gloucester Point and the mouth of the York become naturally depleted of oxygen in warmer weather. The model reproduced this feature.

Phytoplankton growth in the York tends to be light-limited and secondarily nutrient-limited. Sensitivity tests in the model indicate that the nutrient enrichment required to achieve a "bloom" greatly exceed the magnitude of known point and nonpoint sources.

DESIGN OF AQUACULTURE RESEARCH FACILITIES: A COMPUTERIZED APPROACH FOR BIOLOGISTS. J. S. Heaton\*, and P. J. Anninos\*. Inst. of Oceanography, Old Dominion Univ., Norfolk, Va. 23508

Lack of ability to evaluate an aquaculture system often leads to the construction of very general designs, which may require extensive modifications before meeting specific requirements. By applying fluid dynamics' equations to an iterative program base, a mechanism for specific assessment of a system develops.

This computer program is presented for the biologist interested in evaluating any hypothetical system. By entering desired turnover rate, system capacity, pipe sizes, no. of valves, elbows, and orifices, this program calculates the height necessary for the reservoir tank and the horsepower (kilowatt) requirement to lift to that reservoir. The program allows simple analyses of various system configurations, turnover rates, and capacities, as well as determining cost-benefit relationships of pipe versus pump sizes.

EVALUATION OF THE USE OF ALEWIFE (ALOSA PSEUDOHARENGUS) AS A FORAGE SPECIES IN SOUTHEASTERN RESERVOIRS. C. C. Kohler and J. J. Ney. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

In recent years, the anadromous alewife (Alosa pseudoharengus) has been introduced into several southeastern reservoirs. The risks and benefits of establishing alewife populations in southeastern reservoirs have not been evaluated. Observations from the Great Lakes and other freshwater sites indicate alewife might enhance production of piscivorous fish. However, alewife have also been reported to adversely affect recruitment of desirable species, possibly through trophic competition or predation on early life stages.

Alewife were established in Claytor Lake, Virginia by 1970. Piscivorous utilization of alewife was documented by 1972. Alewife growth has declined dramatically since 1971. The decline indicates that intraspecific competition has intensified with a larger population and/or that the original food base or large zooplankters has been diminished. The population is being studied to evaluate its impact on resident fish species through feeding relationships. Initial efforts have focused on the feeding habits of young-of-the-year sport species. Sport fishes less than 50 mm had diets similar to alewife, feeding predominantly on large cladocerans and copepods.

SEDIMENTATION RATES IN THE HAGUE, NORFOLK, VA., BEFORE AND AFTER DREDGING. R.E. Johnson, Inst. of Oceanography, Old Dominion Univ., Norfolk, VA. 23508.

The Hague is a semicircular tidal basin 2,100 feet in diameter connected at the midpoint of its circumference to the Elizabeth River. Depths vary from 0 to 10 feet below mean low water. It is the bulkheaded remnant of two tidal streams. Filling their upper reaches early in this century reduced tidal velocities in the basin to a point where silting occurs. Rain runoff adds still more sediment and its velocity is insufficient to scour the bottom. As a consequence repeated dredging has been necessary.

Analysis of sedimentation as revealed by five sounding surveys from 1931 to 1972 shows shoaling over most of the Hague. The mean rate was +0.11 ft/yr. The Hague was dredged again in the summer of 1974. New sedimentation rates calculated between 1974 and 1978 give a mean value of 0.06 ft/year. Dredging of a portion of the east arm within 20 years seems likely.

APPROACHES TO THE MANAGEMENT OF NON-POINT SOURCE POLLUTION IN THE LOWER JAMES RIVER BASIN. Walter I. Knausenberger. Dept. of Entomology, VPI & S.U. Blacksburg, VA 24061.

The lower James River Basin (downstream from fall line) is examined in the light of the spatial distribution of likely significant non-point sources of pollution (NPSP) and the institutional jurisdictional overlaps and gaps with respect to NPSP in this area. The aggregate magnitude and complexity of combined NPSP is not sufficiently appreciated by decision-makers, citizens and even some environmental scientists. Of the at least 15 State agencies with some NPSP jurisdiction in the region in question, 6 are involved in the NPSP Coordinating Committee; the latter has one-sided emphasis on management of sediment sources (but the Dept. of Highways is not a member). The Committee's regulatory function overlaps with that of the State Water Control Board. Little or no formal coordination exists among local and regional governmental bodies, nor is the contribution of private conservation or civic interest groups, or of water resources enterprises sought. There seems to be a distinct lack of emphasis on interdisciplinary research and of scientific input into decision-making. The monitoring network is inadequately developed. This paper suggests the need for greater attention to aquatic biological monitoring as a uniquely sensitive tool in the assessment of multiple environmental stresses. Higher priority should be placed on the elaboration of a coordinated data acquisition and dissemination system, with a watershed focus.

THE SULFUR DIOXIDE DILEMMA: FUTURE MEASUREMENT NEEDS FROM AN AIRBORNE LIDAR. J. I. Mikula\* and G. E. Copeland. Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

A computer program is employed to simulate the return signals from an airborne UV DIAL system, while flying over a power plant plume which contains particulates, sulfur dioxide ( $\text{SO}_2$ ), and ozone ( $\text{O}_3$ ). The design of the program allows the user to specify certain physical input conditions which are inherent to the return laser signals and subsequently the  $\text{SO}_2$  profile. The standard Gaussian diffusion model is employed to provide a guide for modelling the behavior of the laser signals in regard to the retrieval of the diffusion coefficients. To simulate "real" data, random noise is added to the signal in an amount proportional to the square root of the theoretical concentration. Additional programs are implemented to generate answers for a respective data fit of the form:

$$Z = A_4 + A_1 \exp \left[ -1/2 \left( \frac{(y-A_2)^2}{(A_3)^2} \right) \right], \text{ where } y \text{ is the cross}$$

wind direction, Z is the concentration burden,  $A_1$  is the amplitude,  $A_2$  is the effective stack height,  $A_3$  are the diffusion coefficients, and  $A_4$  represents the background. Retrieval of the four constants is accomplished by a non-linear least squares grid fitting program for the total  $\text{SO}_2$  burden.

\*In Partial Fulfillment of the Master of Science Degree in Atmospheric and Earth Sciences

AN INVESTIGATION INTO THE NUMERICAL SIMULATION OF LONG TERM TRANSPORT OF OCEAN DUMPED SEWAGE SLUDGE IN THE NEW YORK BIGHT. T. D. Modena\*, R. S. Chapman\*, and C. Y. Kuo. Dept. of Civil Engrg., Old Dominion Univ., Norfolk, Va. 23508

An existing three-dimensional Eulerian-LaGrangian finite difference model is modified and used to examine the surface transport of sewage sludge in the New York Bight. Both in-situ and remotely sensed field data are utilized in an attempt to approximate model inputs such as, mean current speed, horizontal diffusion coefficients, particle size distributions and specific gravities. The results presented are a quantitative description of the fate of a negatively buoyant sewage sludge plume resulting from an instantaneous barge release. A means of more effective acquisition of remotely sensed data is suggested so that specific model inputs may be refined in order to attain the final goal of model calibration and verification.

TECHNOLOGY OF STREAM HABITAT IMPROVEMENT IN MOUNTAINOUS WESTERN VIRGINIA. J. J. Ney and K. L. Nelson. Dept. of Fisheries and Wildlife Sciences. Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The goal of stream improvement is to increase angler satisfaction. Objectives include enhancement of fish production, accessibility, and aesthetics.

Fish production in high-gradient mountain streams is limited primarily by seasonal lack of cover due to characteristic poor pool:riffle ratios and summer low flow conditions. Improvement efforts in Virginia have concentrated on adding cover through the addition of dams, gabion deflectors and instream boulder emplacements. We analyzed the success of these devices in terms of fish utilization, durability, and aesthetics on four Virginia streams. All devices provided cover which was heavily used during late summer. Largest pools were formed by log dams. Properly installed log dams were also more stable against floods than boulder emplacements or gabions. Boulder emplacements appear most natural and gabions most artificial. All devices improve angler access by providing cover which is used by the fish and perceived as such by the fishermen. Success of any device is contingent on analysis of hydrodynamic properties of the subject stream.

BALLOON MEASUREMENTS OF OZONE CONCENTRATION IN THE SUMMER PLANETARY BOUNDARY LAYER AT WALLOPS ISLAND, VIRGINIA. C. L. Parsons\*. NASA Wallops Flight Center, Wallops Island, VA 23337

The applicability of NASA's Electrochemical Concentration Cell (ECC) Ozone Balloon for measuring ozone concentration in the planetary layer was evaluated during the summer of 1977. In two separate experiments, one in July and the other in September, balloons were released at the rate of approximately four (4) per day for three consecutive days. The ozone concentration, ambient temperature, relative humidity, wind speed, and wind direction profiles from these balloons have been used to construct time cross sections of these five parameters for both experiments. Preliminary analysis of these data products has resulted in the following conclusions. 1) The ECC ozone Balloon, although designed to monitor the total atmospheric ozone profile, does a creditable job of characterizing the ozone content of the boundary layer. 2) The summertime ozone near the earth's surface at Wallops Island is primarily affected by photochemistry and the movement of synoptic-scale air masses. 3) The upper extent of the enhanced surface ozone concentration layer is not usually at the level of the traditionally determined mixing height but is near the level of the maximum relative humidity gradient.

EFFECTS OF ENTRAINMENT ON THE FISH COMMUNITY OF THE NEW RIVER GLEN LYN, VA. W.A. Potter\*, K.L. Dickson, J. Cairns, Jr. Dept. of Biology, VPI & SU, Blacksburg, VA. and J.R. Stauffer Jr. Dept. of Biology, Frostburg State Col. Frostburg, MD.

The loss of organisms to cooling water intakes has been identified as having an impact on aquatic biota. Entrainment of organisms is unavoidable if natural waters are to be used by utilities for cooling water purposes. The present study was initiated to determine the effects of operation of the Glen Lyn Power Station (GLPS) on the fish community of the New River. Sampling began in late May 1976 and continued through May 1977. Drift nets were utilized to determine both the river drift and entrainment larval fish populations.

An estimated 30,200,000 larval fish of an estimated 172,000,000 that drifted by the GLPS during June 1976 through May 1977 were entrained by the power station. Larvae of the carp (*Cyprinus carpio*) accounted for 94.8% of the ichthyoplankton drift. Estimates of 14.5 to 21.7% of the larvae of selected representative species that drifted by the power station were entrained. It was concluded that the losses of larval fishes to the cooling water intake were not significant enough to affect the fish community structure of the New River near Glen Lyn, Virginia in its present condition.



DESIGN OF THE REGIONAL OZONE STUDY OF EASTERN VIRGINIA FOR SUMMER 1977. J. A. Salop,\* State Air Pollution Control Board, Hampton Roads Regional Office, Virginia Beach, Va., and G. E. Copeland, Physics Dept., Old Dominion University, Norfolk, Va. 23508

The Tidewater area of southeastern Virginia has violated the standard for photochemical oxidants on a continuing basis since the inception of the Hampton Roads Regional office monitoring network in 1972. Considering the unique geography of the area with its extensive embayment, the presence of natural hydrocarbons caused by the multitude of flora, and the known existence of the transport phenomena of ozone and ozone precursors from other areas, a study was initiated in order to provide initial answers to a complex problem. With the able assistance of Old Dominion University, Langley Research Center, Wallops Flight Center, and V.P.I., the Virginia State Air Pollution Control Board was able to establish a (primary) network of stations along a line of bearing analogous to the predominant wind direction and collect data during the critical months of June, July, and August, 1977. Existing ozone monitoring stations in the other areas of Virginia also provided data for large scale analysis.

COLLECTION AND ANALYSIS OF METEOROLOGICAL DATA FOR REGIONAL OZONE STUDY OF EASTERN VIRGINIA FOR SUMMER 1977. J. E. Smith,\* Department of Physics & Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508

The period of this study was from 1 June through 31 August 1976. For each day, a 1200Z surface and 2000 ft. stream line analysis of wind flow was made covering the eastern half of the United States. These analyses provide a continuity of the movement of weather systems through the study area, as well as a generalized reflection of the source region of the air being monitored.

During selected periods of high ozone measurements, six hourly surface data were plotted on sectional charts covering an area from northern New York and southern Maine to central North Carolina and from central Virginia into the western Atlantic (70° W Longitude). The streamline flow patterns on these charts were used to estimate the trajectory of the air parcels and the possible source of the monitored pollutants.

Additionally, 8 years of surface data (1965-1972), at Norfolk International Airport (3 hourly) and Chesapeake Light Station (6 hourly) were used in comparing off shore, versus coastal, diurnal wind variation during the months of June, July, and August. Afternoon seabreeze development becomes quite apparent in the 3-hourly analysis of the monthly average direction and speed of the wind. A predominant south-westerly air trajectory is also apparent.

REMOTE MONITORING OF THE GRAVELLY RUN THERMAL PLUME AT HOPEWELL AND THE THERMAL PLUME AT THE SURREY NUCLEAR POWER PLANT ON THE JAMES RIVER. T. A. Talay,\* NASA Langley Research Ctr., Hampton, Va. 23665, K. W. Sykes, III,\* and C. Y. Kuo, Old Dominion University, Norfolk, Va. 23508

Remote sensing of thermal discharges entering rivers and estuaries provides synoptic spatial and temporal distributions not readily available by other means. These data form a basis for analytical investigations into the dynamics of the discharge patterns.

On May 17, 1977, a remote sensing experiment was conducted by NASA Langley Research Center on the James River, Virginia, whereby thermal spectrometer and near-infrared photography data of thermal discharges at Hopewell and the Surrey nuclear power plant were obtained by an aircraft for one tidal cycle. These data were used in subsequent investigations into the near-field discharge trajectories.

For the Gravelly Run thermal plume at Hopewell, several empirical expressions for the plume centerline were evaluated by comparisons of the computed trajectories and those observed in the remote sensing images. Results ranged from good to poor with bathymetry and flow interference considered causes for the areas of nonagreement. A separate study of the Surrey nuclear power plant plume near Hog Island used a vector composition of the tidal-river flow and the discharge velocity of the thermal source. This solution to the plume centerline trajectory provided good comparisons with the observed remote sensing images.

QUASI-REAL TIME CO MEASUREMENTS FROM A GAS FILTER CORRELATION. J. B. Shaw, Jr.\* Dept. of Physics, Old Dominion Univ., Norfolk, Va. 23508

A procedure for rapid on-the-spot data reduction for a NASA gas filter correlation radiometer (GFCR) is described. An outline is made of the functioning of the GFCR and its current data reduction techniques. The development of the new procedure is summarized and its accuracy is evaluated based on the previously accepted methods. This new procedure will allow quasi-real time retrieval of carbon monoxide concentrations and surface temperatures to within accuracies of 20% and 2% respectively.

RELATIONSHIPS BETWEEN NITROGEN ASSIMILATION AND PHYTOPLANKTON PRODUCTIVITY IN THE PALICO RIVER, NORTH CAROLINA. D.W. Stanley\*, Biol. Dept., George Mason Univ., Fairfax, Va. 22030

Six stations in this estuary (salinity 0 - 20 ppt) were sampled over a 21 month period in a study of nitrogen and phosphorus dynamics. Nitrate levels above 1 ug-at. N/liter occurred only during winter and only at upriver stations. More ammonia than nitrate was present downriver (1 - 4 ug-at. N/liter) but the concentrations followed no obvious seasonal pattern. Dissolved organic nitrogen (5 - 20 ug-at. N/liter) also showed no seasonal pattern. Particulate nitrogen was highest upstream (10 - 30 ug-at. N/liter) and in the middle of the river during late winter algal blooms.

Nitrate uptake (measured with N-15 techniques) ranged up to 0.3 ug-at. N/liter/hr, and usually was less than ammonia uptake (up to 1.0 ug-at. N/liter/hr). Calculated  $Q_{10}$ 's averaged 1.39 for ammonia and 1.63 for nitrate (10°-20°C). Dark ammonia and nitrate uptake were 76% and 31%, respectively, of uptake in the light. Experiments showed that uptake and concentration could be related by rectangular hyperbolas, and that the half-saturating concentrations were 1 to 2 ug-at. N/liter. There was a high phytoplankton preference for ammonia over nitrate. A relative preference index indicated that ammonia concentrations over 1 ug-at. N/liter almost totally suppresses nitrate utilization. (Funded by Water Resources Research Institute grant to Dr. Edward J. Kuenzler, Univ. of North Carolina, Chapel Hill).

PRELIMINARY MEASUREMENTS ON THE APPLICABILITY OF THE WATER HYACINTH (*EICHHORNIA CRASSIPES*) AS A BIOLOGICAL FILTER IN VIRGINIA. K. W. Turgeon\* and J. E. Alexander\*, Marine Science Consortium, Wallops Island, VA 23337.

Plants were held in the field under three sets of environmental conditions during the fall of 1977. The results demonstrated that, under fall conditions of decreasing temperatures, the productivity of plants held in an open pond was increased by enclosing them in a floating, double-layered polyethylene greenhouse. The greenhouse, however, did not influence the survival period of the plants.

Plants held in a land-based, insulated tank covered with a double-layered polyethylene greenhouse exhibited a high and temporally extended period of productivity. Whereas both groups of plants in the open pond fragmented and disintegrated upon death. The plants in the land-based greenhouse remained intact throughout the winter and are regenerating during the spring period of increasing temperatures.

These findings have application to regional interests in utilizing the water hyacinth as a biological filtration system for upgrading the quality of wastewater effluents.

HIGHWAY-GENERATED HEAVY METAL CONTAMINATION STREAM ECO-SYSTEMS. J. H. van Hassel\*, J. J. Ney, and D. L. Garling\*. Dept. of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

The distribution of contaminating waste products to the environment adjacent to our nation's highways is receiving belated attention. Among these contaminants are heavy metals, including lead from gasoline engine exhausts, nickel from combustion of lubricating oil, and cadmium and zinc from tires. Research has demonstrated the toxicity of low concentrations of these metals to aquatic organisms, especially in soft-water environments such as are found in western Virginia. Investigations of highway-generated heavy metal contamination of stream ecosystems have been extremely limited but provide reason for concern. We have found concentrations of heavy metals to be several times greater than baseline levels in both fish and sediments of a stream associated with a highway travelled by 15,000 vehicles/day. These results indicate that contamination impact on aquatic populations may be severe. Heavy metal concentrations vary with traffic densities, trophic levels, and season. These relationships must be described prior to impact assessment.

PRELIMINARY RESULTS OF THE 1977 SURFACE OZONE INVESTIGATION IN THE EASTERN SHORE - TIDEWATER AREA OF VIRGINIA AND NORTH CAROLINA. M. E. Williams\*, NASA Wallops Flight Center, Wallops Island, VA 23337

During the summer of 1977 the Wallops Flight Center along with other governmental and educational organizations participated in a surface ozone investigation conducted by the Virginia State Air Pollution Control Board. A network of twelve ground stations was positioned in the Eastern Shore - Tidewater area of Virginia and North Carolina. From an analysis of the ozone and wind data certain trends were found such as the existence of a bias in the ozone concentrations between stations and a linear correlation between average ozone concentration and latitude. In addition, higher ozone levels were found with surface winds from certain preferred directions at the various sites. These directions did not correspond to those azimuths along which ozone and precursor transport was expected.

## Section of Geology

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

A GEOLOGICAL AND GEOPHYSICAL STUDY OF THE GREEN SPRINGS, PLUTON, LOUISIA COUNTY, VA. W. Roger Buck\*, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

The Green Springs Pluton is a body of igneous rock of magmatic origin that is surrounded by metasedimentary rocks in the Piedmont of Virginia near Poindexter. The pluton crops out over an area of fifteen square miles and is expressed as an aeromagnetic high and a topographic low.

Field work combined with thin section and x-ray studies shows great variation in rock type. Most of the pluton is rimmed by rocks containing greater than ninety percent hornblende which grades into rocks of up to eighty percent feldspar content. An area of three square miles in the eastern part of the pluton lacks this rim and contains less than five percent mafics on average. This indicates a later phase of injection. Other evidence for this view is the rounding of xenoliths and gradational contacts with country rock in the main part of the body while the contacts in the low mafic area are sharp. Gravity data indicates that the pluton slopes off to the east beneath the surface.

I gratefully acknowledge the advice and information given by Stanley S. Johnson of the Virginia Division of Mineral Resources.

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TRACING THE ORIGINS OF RED EARTHENWARES THROUGH CLAY CHEMISTRY. Stephen C. Clement, College of William and Mary, Williamsburg, Virginia 23185

Examination of 17th century artifacts by x-ray spectroscopy indicates that the titanium content may serve as a diagnostic tool to separate red earthenwares made of local clays from those imported from England. In cooperation with the Dept. of Archeology of the Colonial Williamsburg Foundation, a series of pot sherds and clays from the vicinity of Carter's Grove Plantation were analysed. As expected, major elements present include aluminum, silicon, iron and calcium, with smaller amounts of potassium and titanium. Of all the elements, only the ratio of the integrated intensities of the K alpha peaks of titanium to potassium appears to give a positive correlation. Local clays and locally made earthenwares contain significantly higher titanium contents and ratios. Firing of local clays to 2000°F. does not appear to affect the titanium - potassium ratio. The titanium is attributed to rutile or ilmenite in the Coastal Plain sediments. Sources for these minerals may be the nelsonites and anorthosites of Roseland or Montpelier or, more probably, the broad expanse of eastern Piedmont rocks metamorphosed to the sillimanite grade.



POTHOLES AT THE FALLS OF THE JAMES RIVER IN RICHMOND, VIRGINIA. Bruce K. Goodwin, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

The James River crosses the Fall Zone at Richmond, Virginia. There the river has extensive rapids in its bed of Petersburg granite for a distance of about seven miles extending westward from I-95. Potholes occur in the granitic rocks throughout the Fall Zone, but optimum pothole development occurs in an area south of Belle Isle and west of the Robert E. Lee Bridge, where during low water stages broad areas of the granite river bed may be completely dry. During flood stages the bedrock is covered by several feet of turbulent water.

Potholes, varying in diameter and depth from a few inches to over five feet, abound on the granite's surface. Several hundred potholes occur and their development has been a strong factor in erosion of the bedrock. Many elliptical potholes follow prominent joints and most of the potholes, both elliptical and circular in outline, are localized by some inherent structural feature of the granite. These features are ones which caused initial irregularities in the surface of the granite being subjected to stream erosion. Common controls of pothole localization are joints, joint intersections, minor faults, gneissic banding, and strong contrasts in lithologies at the borders of sills, dikes, veins and xenoliths. Joints, occurring either as open or closed fractures, have been dominant sites of pothole development.

A CHRONOSEQUENCE OF SOILS DEVELOPED IN NEW RIVER ALLUVIUM. W. G. Harris, J. L. Richardson, and D. A. Lietzke. Dept. of Agronomy, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061

A flood plain soil ( $T_0$ ) and three terrace soils ( $T_1$ ,  $T_2$ ,  $T_3$ ), formed in progressively older New River alluvium, were described and sampled in order to study the influence of time on soil formation. Chemical and physical lab. analyses were conducted for all horizons and sand mineralogy was determined for the control section of each pedon. Properties found to increase with soil age included clay illuviation, acidity (i.e. lower pH, higher KCl extractable Al, and higher  $BaCl_2$ -TEA acidity), subsoil redness, and dithionite-extractable Fe. However, acidity decreased slightly from  $T_2$  to  $T_3$ . Organic matter, available P, base saturation, and weatherable sand-sized minerals decreased with age. Higher acidity and lower base status for  $T_2$  and  $T_3$  could be attributed to more thorough leaching with time. The decline in acidity from  $T_2$  to  $T_3$  may be reflecting an advance stage of weathering where permanent charge acidity is being reduced. Sand mineralogical data as well as geomorphological evidence indicate that  $T_0$  and  $T_1$  occur on closely related surfaces which are much younger than the higher terraces.

MINERAL DISPERSAL IN HAWKSBILL CREEK DRAINAGE BASIN, EASTERN ROCKINGHAM COUNTY, VIRGINIA. R. A. Johnson, Department of Geology, James Madison University, Harrisonburg, Va. 22801

Feldspar content decreased from approximately 80 percent in the granitoid Pedlar Fm at the head of Hawksbill Creek to less than 3 percent in the stream bed 1.5 km downstream (gradient 183 m/km), then abruptly increased to nearly 30 percent at the confluence with a lower gradient (49 m/km) tributary, then gradually decreased to less than 10 percent at the boundary between the Catocin and the Chilhowee Group quartzites, at which an increase to approximately 16 percent occurred. The ratio between K-feldspar and plagioclase increased from nearly 1:1 in the Pedlar bedrock to 2:1 in most soil and stream samples. Quartz content increased from 20 percent in the Pedlar to 30 percent in the overlying soil but polycrystalline quartz decreased from nearly 100 percent to 25 percent in the soil. The quartz content of stream samples in the upper 1.5 km varied from 25-35 percent; the percentage of polycrystalline quartz decreased from 65 to 30 percent in that same distance, while the quartz content of stream samples increased to 40 percent at the confluence of the tributary and varied from 35-40 percent downstream. Stream relief and instability of feldspars and polycrystalline quartz and breakdown to sizes finer than medium sand are the major causes of the changes observed.

RECONNAISSANCE OF THE METAMORPHIC GEOLOGY OF PITTSYLVANIA COUNTY, VIRGINIA. Joel P. Gregory\*, College of William and Mary, Williamsburg, Virginia 23185

Pittsylvania County is located just north of the Virginia North Carolina boundary and is situated in the Piedmont physiographic province. High grade metamorphic rocks in the county are divided into two areas by the Danville Triassic basin. Rocks on both sides of the basin consist of Precambrian gneisses overlain by Precambrian metamorphosed volcanic sediments.

The structure of the rocks in Pittsylvania County is highly complex, and there is ample evidence of polyphase metamorphism. Though trending generally in a northeast-southwest direction, these rocks are greatly distorted and dip variably in several directions.

Heavy mineral analysis of stream sediments taken from the study area indicates an increase in metamorphic grade from the southeastern portion of the county to the northwestern portion, west of the Danville basin. An increase from kyanite to sillimanite grade occurs, with the sillimanite isograd falling approximately half-way between the western margin of the Danville basin and the western boundary of Pittsylvania County. This isograd trends generally north-northeast. Some areas in the central portion of the county contain both kyanite and sillimanite, other areas in the extreme northern part of the study area contain sillimanite but no kyanite.

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OBSERVABLE CHANGES IN SOIL PROFILES IN A LOAM TEXTURED TOPOSEQUENCE IN VIRGINIA BEACH. D. R. Hatch, G. R. Swecker, J. L. Richardson, and J. E. Belshan. Dept. of Agronomy, Va. Polytechnic Institute and State Univ. 24061

A study of four major soils in a Virginia Beach toposequence: a well drained Typic Hapludult, a moderately-well drained Aquic Hapludult, a somewhat poorly drained Aeric Ochraqult, and a poorly drained Typic Ochraqult demonstrated that minor topographic variations were reflected in depth to seasonal water table and soil color.

The well drained soil and upper portion of the moderately well drained soil lie above the seasonal water table and seldom have saturated flow drainage for prolonged periods, resulting in unmottled, bright subsoil colors. The lower part of the moderately well drained soil and the upper part of the somewhat poorly drained soil are subject to temporary water table saturation resulting in saturated flow which causes iron reduction on the surface of soil peds. Ped centers are initially drier and draw water inward by capillarity, removing iron from the ped faces and resulting in gray ped exteriors that grade inward to bright ped interiors. The poorly drained soils and lower parts of the somewhat poorly drained soils are subject to prolonged wetness by stagnant water causing loss to solution of ferrous iron, producing gleyzation (grayness). Brighter mottles are remnants of original oxidized iron.

STRUCTURAL GEOLOGY AND ENGINEERING PROBLEMS ALONG THE PRICES FORK EXTENSION (RT. 659) IN THE PRICE MOUNTAIN WINDOW, MONTGOMERY COUNTY, VA. N. E. Johnson\*, Dept. of Geology, VA Polytechnic Inst., Blacksburg, Virginia 24061

Price Mountain is an anticlinal structure in the Saltville fault block and forms a window in the Pulaski thrust sheet. The window rocks consist of Mississippian red shales, siltstones, and fine-grained sandstones. The rocks surrounding the window consist of Elbrook dolomite, which is an argillaceous dolomite with shale interbeds. The Elbrook is highly fractured, locally mineralized and is characterized by a karst topography.

Problems encountered along Rt. 659 in and adjacent to the Pulaski fault include: 1) slides in weathered and brecciated fault material. 2) reactivation of inactive sinkholes 3) slide-prone quasihomogeneous fault gouge consisting of several lithologic types including Millboro shale, Silurian quartzite and Ordovician limestone. Possible solutions to these problems include improvement of drainage, reduction the angle of slopes, and relocation of the road in at least one area.

DESIGN CONSIDERATIONS IN A LABORATORY TYPE SEISMIC SYSTEM. James D. Lehman, Dept. of Physics, James Madison Univ., Harrisonburg, Va. 22801

Little work has been done to bring first-hand seismic phenomena into the educational setting. The feasibility of an indoor seismic system is surveyed to determine operational constraints in that environment. Construction details of the working models call for economy, simplicity, and the use of commonly available materials.

Performance of a long period and a short period sensor at ground floor level are compared, and limits of the system determined. Event readings include natural earthquakes as well as atomic tests, quarry blasts, and daily changes in microseisms. Recording detail is sufficient to note signatures, arrival phases, dispersion, and directional characteristics. Speculation as to magnitude and the depth of focus are possible.

SULFOSALTS FROM THE COFER DEPOSIT, LOUISA COUNTY, VIRGINIA. J. W. Miller, Jr.\* Dept. of Geological Sciences, Va. Polytechnic Inst., Blacksburg, Va. 24061

The Cofer deposit is a stratiform volcanogenic massive sulfide deposit located in the old Virginia Gold-Pyrite Belt near Mineral, Louisa County. It was discovered as a geochemical anomaly in the 1950's.

Typical ore occurs as unoriented subhedral pyrite ( $\text{FeS}_2$ ) (.5-3mm) and anhedral sphalerite ( $(\text{Zn}, \text{Fe})\text{S}$ ) (.1-3mm) intermixed with varying amounts of silicates. Galena ( $\text{PbS}$ ) and chalcopyrite ( $\text{CuFeS}_2$ ) may be locally abundant (usually <1mm). Also present are arsenopyrite ( $\text{FeAsS}$ ) and traces of electrum ( $\text{Au}, \text{Ag}$ ). The sulfosalts are widely scattered and include tetrahedrite-tennantite ( $(\text{Cu}, \text{Ag}, \text{Fe}, \text{Zn})_{12+x}(\text{Sb}, \text{As})_{4+y}\text{S}_{13}$ ), kobellite-tintinaite ( $\text{Pb}_5(\text{Bi}, \text{Sb})_8\text{S}_{17}$ ), cosalite ( $\text{Pb}_2\text{Bi}_2\text{S}_5$ ), and gudmundite ( $\text{FeSbS}$ ). Tetrahedrite-tennantite ranges from the antimony end-member, which is usually silver bearing ( $\leq 20$  wt. % Ag), through the arsenic end-member. It may occur as grains (<1mm) associated or included in galena, or associated with arsenopyrite and chalcopyrite. Kobellite-tintinaite occurs as lamellae ( $\leq 1$ mm) in chalcopyrite associated with coarse, euhedral pyrite. Kobellite-tintinaite contains approximately equal amounts of antimony and bismuth and has apparently exsolved native bismuth. Cosalite occurs in grains (.05-.5mm) closely associated with chalcopyrite and galena. Gudmundite is found only occasionally as tiny ( $\sim 0.1$ mm) grains in chalcopyrite associated with coarse pyrite sections.

RELATIONSHIP OF THE SOILS TO LANDSCAPE OVER THE LOVINGSTON FORMATION IN GREENE COUNTY. R. W. Rhodes, D. E. Starner, and J. L. Richardson, Dept. of Agronomy, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061

The Lovingston Formation is a quartz biotite granite gneiss with lithology changing from west to east. The quartz decreases and mica content increases in the eastern segment. The saprolite is thick over ridgetops and thin to absent on the sideslopes. Mapping units, established by field characteristics, exhibit a close relationship to landscape position and landform type. Soil type is predictable from landscape position, slope gradient, and shape. Four units were established on the eastern segment: Unit 26 on convex summits with 2-7% slopes; Unit 34 on the convex shoulders and narrow interfluvies with a dominant 7-15% slope; Unit 4 on straight steep backslopes with 15-25% slopes; and Unit 7 on concave footslopes and heads of drains usually with 2-7% slopes.

Soil samples were analyzed and compared for the following: available water, depth to clay maximum, clay % and pH of the B<sub>2t</sub> horizons, and depth of solum. The results showed that Unit 26 was in a stabler landscape position and able to reach a more mature state of soil development than Units 34 and 4. Units 34 and 4 are the high erosion environments in the landscape which keeps their soil profile development at a more youthful age than Unit 26. Unit 7 soil profile development is controlled more by deposition rather than erosion.

CHARACTERIZATION OF SYNTHETIC BLUE DIOPSIDE CRYSTALS. Henry D. Schreiber, Department of Chemistry, Virginia Military Institute, Lexington, Va. 24450

Chromium-rich diopside crystals, when synthesized in air at high temperature from silicate melts, are often colored a characteristic blue. Chromium, in its common Cr(III) state, usually imparts a green color to most silicate minerals. Indeed, chromium-rich diopside is colored green, if synthesized under conditions more reducing than those that resulted in the blue diopside.

The cause of the anomalous blue color of the synthetic diopside has been ascribed by various authors to the presence of Cr(II) ions, low-spin Cr(III) ions in tetrahedral lattice sites, Cr(IV) ions, and lattice defects. In order to investigate the basis of its color, the synthetic blue diopside crystals have been characterized by absorption spectra, electron paramagnetic resonance, magnetic susceptibility, chromium substitution mechanisms, crystallization studies, and chemical redox analyses. Most measurements tend to support the hypothesis that a small but significant amount of chromium as Cr(IV) in the diopside lattice will produce the unusual blue color.

MINOR STRUCTURES INDICATING TWO PHASES OF DEFORMATION NEAR FREDERICKSBURG, VIRGINIA. J. G. SNYDER\*, AND R. V. AMENTA, DEPARTMENT OF GEOLOGY, JAMES MADISON UNIVERSITY, HARRISONBURG, VIRGINIA 22801.

Metasedimentary rocks of the Fredericksburg Complex exposed along the Rappahannock River near Fredericksburg, Virginia exhibit minor structures relating to two phases of deformation, D<sub>1</sub> and D<sub>2</sub>. Analysis of these structures, including folds, lineations and schistosity, supports a model of major polyphase folding proposed by Pavlides (1976) in which a doubly plunging synform is refolded by an antiform. F<sub>1</sub> minor folds are upright and isoclinal with axes and sparse lineations plunging steeply northeast. F<sub>2</sub> minor folds are also upright and isoclinal but with axes and ubiquitous lineations plunging gently northeast and southwest. A third, weakly developed lineation consists of elongated micas which probably developed parallel to the direction of maximum finite elongation during D<sub>2</sub>. The schistosity is crenulated in the hinges of the F<sub>2</sub> folds, but its relationship to the hinges of the F<sub>1</sub> folds is unclear. The ages of deformations D<sub>1</sub> and D<sub>2</sub> is uncertain. If the Fredericksburg Complex is equivalent to the Quantico Slate, which is presumably Ordovician, then both deformations may be Taconic or younger.

USES AND MISUSES OF KARST TOPOGRAPHY --WITH EXAMPLES FROM ROCKBRIDGE COUNTY, VIRGINIA. E.W. Spencer, Dept. of Geology, Washington & Lee Univ., Lexington, Virginia. 24450.

The potential hazards which exist when development occurs in areas of karst topography have generally been ignored by planners and developers in western Virginia. Development is encroaching on areas of karst in many places and geologists should consider their responsibility for informing local government officials and developers about the hazards involved. Even well educated officials, planners, and engineers may think that karst areas are inactive or that they will be detected by soil surveys or by coring on construction sites. Hazards of many types are involved in the Rockbridge County area and include the collapse and subsidence of the ground surface over sinks, but more subtle hazards may arise from use of sinks for waste disposal, and it is not uncommon for a house to employ both a well and a septic field both located within the same sink hole. I64 has been constructed across one of the largest sinks in Rockbridge County, and industrial and commercial development is planned in this same area of intense karst development.



## Section of Materials Science

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

OXIDATION OF ILMENITE. L. J. Corsa, III\* and T. P. Floridis Babcock and Wilcox Co., Lynchburg, Va. 24505 and Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061, respectively.

The rate of oxidation of synthetic ilmenite ( $\text{FeTiO}_3$ ) in an oxygen atmosphere was investigated thermogravimetrically in the temperature range from 300°C to 850°C. The products of oxidation were identified by X-ray diffraction. Below 800°C the products of oxidation are pseudorutile ( $\text{Fe}_2\text{Ti}_3\text{O}_9$ ) and hematite ( $\text{Fe}_2\text{O}_3$ ), whereas above this temperature they are rutile ( $\text{TiO}_2$ ) and pseudobrookite ( $\text{Fe}_2\text{TiO}_5$ ). At temperatures above 525°C the oxidation is diffusion-controlled with an activation energy of  $50 \pm 3$  Kcal/mole., and iron as the mobile species.

X-RAY ANALYSIS OF A REACTED TITANIUM FILM ON SILICON. V. H. Gehman, F. Dietrich and C. R. Houska, Dept. of Matls. Engineering, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Thin films of titanium were sputtered onto silicon, single crystal substrates with a 111 orientation. X-ray diffraction analysis of the thin films was conducted to study lattice strain and composition changes after annealing. Bulk powder standards had to be prepared and their diffraction patterns obtained because the lattice parameter and intensity data in the literature are not sufficiently accurate for quantitative film studies. A computer simulation analysis of the thin film data, employing a Tektronix Graphics Terminal, was developed to determine a model of reacted films. Both the Bragg reflections and diffuse scattering are used to determine a model describing the reactions in the titanium-silicon thin film system.

STUDIES OF FRACTURE AND DEFORMED SURFACES OF HIGH STRENGTH ALUMINUM ALLOYS BY X-RAY DIFFRACTION. Tamma K. Kumar\* and Stephen G. Cupschalk, Dept. of Mechanical Engineering and Mechanics, Old Dominion Univ., Norfolk, Va. 23508

X-ray observations of fatigue fracture and deformed surfaces of 7075-T6 aluminum were conducted in this study. The (111) and (222) diffraction peaks were obtained from the fractured and deformed surfaces. It was observed that in comparison with the base metal, the fracture exhibited line broadening similar to that due to cold working. The broadening is indicative of plastic deformation in the vicinity of the advancing crack tip during the fracture process. Also the different regions of fracture exhibited varying degrees of line broadening. With respect to the fatigue crack, the slow crack growth region showed a greater broadening, and, hence, a smaller particle size, than the fast crack growth region. By means of a modified residual stress device, it was determined that the depth of x-ray penetration did not exceed the thickness of the deformed material at the fracture surface. From an analysis of fracture and deformed surfaces, roughness of the fracture was not observed to affect the shapes of x-ray diffraction peaks.

FATIGUE DAMAGE: STIFFNESS STRENGTH COMPARISONS FOR COMPOSITE MATERIALS. T. K. O'Brien and K. L. Reifsnider, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

A reduced stiffness analysis was used in conjunction with laminated plate theory to predict stiffness changes based on observed debonding and fiber breakage for Boron Epoxy laminates subjected to strain controlled fatigue loading. All specimens were leached with a heated acid and fiber breakage was recorded. Correlations are noted between matrix damage and observed changes in load-direction stiffness.

As an extension of this work, an attempt was made to completely characterize all four independent material properties--longitudinal and transverse moduli, shear moduli, and Poisson's ratio--for unidirectional Boron Epoxy laminates using a combination of longitudinal, transverse, shear, and bending tests. Variations in measured material properties with strain gage type and size, as well as other controlled variables, were documented to insure reproducible and comparable results.

STRESS ANALYSIS OF DAMAGED COMPOSITE LAMINATES. A. Talug,\* and K. Reifsnider. Department of Engineering Science and Mechanics, Va. Polytechnic Inst., Blacksburg, Va. 24061

The effects of the progress of damage in the response of fiber reinforced laminated composite materials is investigated via an analysis of the stress states in partially cracked laminates.

A generalized plane strain formulation is employed to establish the stresses in laminates of symmetrical lay up containing through-the-width cracks, and the solution is obtained by the finite difference technique. Influence of damage on the distribution of the stresses within the laminate is studied for various stacking sequences and damage states. Numerical predictions of longitudinal equilibrium spacing of transverse cracks defining a characteristic damage state are also made.

TEMPERATURE DEPENDENT VISCOSITY OF AN ELASTOMER - MODIFIED EPOXY. W. W. Wagner\* and John M. Kuhlman, Dept. of Mechanical Engineering and Mechanics, Old Dominion Univ., Norfolk, Va. 23508

Flow properties of an elastomer - modified epoxy resin (DGEBA) were measured using an Instron rotary rheometer in the cone-and-plate mode. The elastomer and epoxy were either mechanically mixed (9% elastomer by weight), or mixed in the presence of triphenylphosphine, a catalyst (11% by weight). The epoxy, the elastomer, and the two modified epoxies exhibited a linear stress vs strain rate relation for strain rates up to 5000 sec<sup>-1</sup>, over a temperature range of 300K-450K. Normal stress differences were negligible. Viscosities decreased with increasing temperature by factors of approximately 1000. This viscosity decrease occurred at a decreasing rate as the temperature increased. The viscosities of the modified epoxies were close to the viscosity of the epoxy alone at the same temperature. (Work performed at NASA-LARC; W.W.W. supported by NASA Grant NGR 47 - 003 - 052)

## Section of Medical Sciences

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
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NON-ENZYMATIC FORMATION OF METHYLGLYOXAL FROM DIHYDROXYACETONEPHOSPHATE IN RAT LIVER EXTRACT. S.A. Siegal and R.B. Brandt. Dept. of Biochemistry and the MCV/VCU Cancer Center, Medical College of Va., Richmond, Va. 23298

Szent-Gyorgyi and others have suggested that  $\alpha,\beta$ -dicarbonyls have a role in the control of growth. Methylglyoxal (MeG), a keto-aldehyde, is catabolized to D-lactic acid (NOT the L-lactic acid of glycolysis) by the mammalian enzymes glyoxalase I [S-lactoyl-glutathione methylglyoxal lyase, (Isomerizing); EC 4.4.1.5] and glyoxalase II [S-2 hydroxacyl glutathione hydrolase; EC 3.1.2.6], with glutathione as a co-enzyme. There have been previous reports of the enzymatic catalysis of MeG synthesis, but recent research has described the isolation of a bacterial synthetase that catalyzed the formation of MeG from dihydroxyacetonephosphate (DHAP). We have used these purification procedures in an attempt to isolate a comparable enzyme from rat livers. MeG formation was found after incubating partially purified liver extracts with DHAP. No MeG was formed when the liver extracts were incubated with dihydroxyacetone, glyceraldehyde or pyruvate. The continuous coupled MeG assay of Racker and the discontinuous 2,4-DNPH assay of Gilbert and Brandt provided the same results. The catalytic activity was not decreased by heat denaturation. This study indicates the presence of a non-dialyzable, nonprotein catalyst of MeG formation in rat livers with DHAP as substrate.

This research was supported by funds from the National Foundation for Cancer Research and the MCV/VCU Cancer Center.

WIDE RANGE OF EXPRESSIVITY IN A CYSTINURIA ALLELE. R.J. Caldwell,\* J. I. Townsend, and M.J.V. Smith.\* Dept. of Human Genetics and the Div. of Urol., Med. Col. of Va., Richmond, Va. 23298.

Amino acid excretion, measured by ion-exchange column chromatography in random urine samples from 102 members of a human isolate in which a gene for cystinuria was segregating, showed that none of the obligate carriers (parents and offspring of cystinurics) excreted excess cystine. This suggested that the cystinuria allele in this population was completely recessive; however, two other individuals were identified who excreted urinary cystine in amounts in excess of 100 mg/g creatinine, which would suggest that they were heterozygous for an incompletely recessive allele. Calculation of inbreeding coefficients for each member of the population for whom pedigree information was available showed that the average consanguinity of the population was almost equal to that of second cousins. It, therefore, appears unlikely that two rare recessive alleles for cystinuria are present in this population, but instead, that the different levels of cystine excretion most likely represent a wide range of expressivity of one cystinuria allele in different individuals.



MORPHOLOGICAL ANALYSIS OF MATURING DEEP CEREBELLAR NUCLEI. C.W. Christman\*, and J.T. Povlishock\*, Department of Anatomy, Medical College of Virginia, Richmond, VA 23298.

The maturing deep cerebellar nuclei in rats ranging in age from 4 to 24 days of postnatal life were studied by means of both light and electron microscopy. Light microscopic examination demonstrates that the maturation of the deep cerebellar nuclei can be characterized as a progression of neuronal growth and cytoarchitectural differentiation. At the ultrastructural level this maturation involves many subtle and complex morphogenic and synaptic phenomena. At day 4 morphogenesis appears to be confined to the neuronal somata with only occasional sprouting dendritic shafts in evidence. Synaptogenesis comparably appears immature with only infrequent synaptic sites occurring in relation to either the somata or their primary dendritic appendages. Day 8 demonstrates further somal morphogenesis exemplified by cytoplasmic expansion. Proximal dendritic morphogenesis is marked; numerous complex synaptic terminals form contact with the somal surface, its somatic spines and dendritic shafts. By the 14th day of maturation both somal and dendritic morphogenesis appear advanced. The somal surface and proximal dendrites are lined with synaptic terminals, while synaptogenesis appears to be continuing in relation to distal dendritic appendages. Both morphogenesis and synaptogenesis appear completed by the 23rd day, and concomitant with a pronounced degree of myelination the deep cerebellar nuclei now appear relatively mature.

Clemon, H.R.\* and Leichnetz, G.R.\*, THE AFFERENT CONNECTIONS OF THE CAT PREFRONTAL CORTEX: AN HRP STUDY. Department of Anatomy, Medical College of Virginia, Health Sciences Division, Virginia Commonwealth University, Richmond, Virginia 23298.

The mammalian prefrontal cortex, hitherto poorly understood in function, is an area of sensory convergence of systems representing the internal and external milieu. Its afferent projections have been studied in the cat by means of the horseradish peroxidase (HRP) technique. HRP was injected into the gyrus prefrontalis of cats, and, in one case into contralateral adjacent areas of premotor cortex as a control. Histological treatment of brain sections with benzidine dihydrochloride and hydrogen peroxide demonstrated the retrograde transport of HRP to both cortical and subcortical sources of prefrontal afferents. Bright and dark field microscopy were used to study the labelled areas. Cortico-cortical afferents originated in lamina III of the ectosylvian, sylvian and cingulate gyri. Those found in subcortical regions were heaviest in the ventral tier of the thalamus, (VA, VM, VL) and the nucleus medialis dorsalis (MDpc). Labelled cells were also found in the amygdala (Basal, pars magnocellularis), ventral claustrum, and the nucleus centralis medialis. On the basis of this anatomical evidence, the involvement of the prefrontal cortex with limbic function via the cingulate cortex, amygdala and nucleus medialis dorsalis of the thalamus will be considered.

CONTROL OF STAPHYLOCOCCUS AUREUS OSTEOMYELITIS BY MICRO-AMPERE ACTIVATION OF METAL IONS IN MONOMOLECULAR FILMS ON STAINLESS STEEL PINS. G. Colmano, S. S. Edwards, T.E. Lesch, Dept. Veterinary Sci., VPI & SU, and S. D. Barranco, Montgomery Co. Orthopedic Assoc., Blacksburg, Va 24061

Different metals (Ag, Al, Au, Cu, Pt, Zn...) deposited on the surface of surgical stainless steel (ss) pins as stearates in monomolecular layers (Metal St. Film), when ionically activated by 1 hr of 10 microamperes of positive direct current per cm<sup>2</sup> (10  $\mu$ AH/DC/cm<sup>2</sup>) have caused varying degrees of bacteriostasis against *Staphylococcus aureus*, *Proteus vulgaris*, and *Pseudomonas aeruginosa*. AgCe St Films on ss intramedullary pins, treated with 10  $\mu$ AH/DC/cm<sup>2</sup>, were proven bacteriocidal *in vivo* (rabbit and dog) and *in vitro* (petri dishes, agar vials, and broth tubes) for *S. aureus* (3 x 10<sup>3</sup>) and *P. vulgaris* (5 x 10<sup>2</sup>). *In vivo*, one pin with and one pin without current treatment were respectively inserted in the right and left leg of an animal and after 1 hr were extracted, transferred to broth, which was serially diluted, plated, incubated and colonies counted. Trials in establishing a *S. aureus* osteomyelitis in the dog have encountered some difficulties and some degree of success. The ss pins, coated with AgCe St Film, contaminated with *S. aureus*, then inserted into the right and left ulna of a dog, respectively treated and untreated by 10  $\mu$ AH/DC/cm<sup>2</sup>, when extracted and transferred to broth, had *S. aureus* growth only from the left (current untreated side); *S. aureus* was cultured from the left lymph node.

TURNIP YELLOW MOSAIC VIRUS RNA VALINE ACCEPTOR ACTIVITY: AMINOACYLATION KINETICS. R. Clark\*, D. R. Lightfoot, and P. R. Desjardins\*, Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst., Blacksburg, VA, 24061 and Dept. of Plant Pathology, Univ. of Calif., Riverside, CA, 92521.

Turnip Yellow Mosaic Virus (TYMV) RNA (1.9 x 10<sup>6</sup> Daltons) contains a stoichiometric proportion of valine tRNA-like activity when assayed with crude enzymes from bean, yeast, rat and *E. coli*. TYMV RNA prepared in this way appears to be an exceptionally competent substrate for valine tRNA synthetases. With all of the synthetases tested the valylation of TYMV RNA showed first order kinetics at short times and then 85% to 90% charging at completion. The Michaelis constant is 7.4nM for the viral RNA when employing yeast valine tRNA synthetase. This value is 1/3 of that for the homologous valine tRNA and the lowest reported for any tRNA. The viral RNA is charged at 1/2 of the V<sub>max</sub> observed for the homologous yeast tRNAval. Recognition of the viral tRNA by *E. coli* valine tRNA synthetase was characterized by Km=1.2 $\mu$ M whereas the homologous *E. coli* valine tRNA Km=0.4 $\mu$ M. The Km of the bean synthetase is an order of magnitude greater than the Km of the yeast synthetase for TYMV RNA. These data suggest an unusually fine adaptation of the 108 nucleotide viral valine tRNA function toward productive interaction with diverse valine tRNA synthetases. (Supported by Research Corporation).

MYOCARDIAL NECROSIS ASSOCIATED WITH ISOPROTERENOL-INDUCED CALCIUM CHANGES. T. W. Coffey\*, J. L. Poland, F. O'M. Shiel\*, and K. C. Corley. Department of Physiology, Medical College of Virginia, Richmond, Virginia 23298.

Low doses of isoproterenol (isopro) increase myocardial contractility; however, higher doses produce myocardial necrosis. This necrosis has been suggested to result from an energy depletion by an isopro-induced elevation of intracellular calcium (Ca) that excessively activates actomyosin ATPase. The present study investigates in the rat the possibility that this enhanced intracellular Ca involves the sarcoplasmic reticulum (SR). The effects of isopro (500 mg/kg s.c.) were studied 7 min., 1 hr., 6 hrs., 24 hrs. and 48 hrs. after injection. After the rats were sacrificed under sodium pentobarbital anesthesia, the heart ventricles were carefully sectioned into segments for histological studies, total Ca analysis by atomic absorption spectroscopy and SR Ca uptake velocity and capacity. While the total tissue Ca increase correlated with the increase in the histological evidence of necrosis (H and E prepared tissue) from 6 hrs. to 48 hrs., no indication of altered SR Ca uptake velocity and capacity was observed in the ventricular homogenates. Therefore, the isopro-induced necrosis associated with high intracellular Ca levels does not appear to result from a malfunctioning SR. (Supported in part by USPHS, NIH Grant HL # 13454.)

ACETYLCHOLINERASE ACTIVITY IN THE BRAIN STEM OF THE NORMAL AND BRAIN INJURED CAT. W.D. Dietrich\*, J.T. Povlishock\* and D.P. Becker\*, Depts. of Anatomy and Neurological Surgery, Medical College of Virginia, Richmond, Virginia 23298.

The present study constitutes a light and electron microscopic analysis of acetylcholinesterase activity (AChE) in normal and brain injured cats. Additionally, it presents a novel modification of histochemical protocols for the simultaneous light and electron microscopic visualization of AChE activity. Both normal and brain injured animals were perfused transcardially with aldehydes. The brains were removed, and serially sectioned on a vibratome at a thickness of 100 $\mu$ . The serial sections were incubated in media previously described by Lewis and Shute, *J. Cell Sci.* 1, 1966. Alternate serial sections were then either dehydrated, cleared and mounted for light microscopic analysis or were further processed for electron microscopy. In employing such a protocol we were able to observe rich AChE activity in the motoneuronal, precerebellar and other well outlined centers. Ultrastructural examination of these nuclear groups revealed AChE concentrated in the rough endoplasmic reticulum, nuclear envelope and postsynaptic membranes.

In traumatized animals following one hour survival, the enzymatic activity appeared enhanced in many nuclear groups being extremely prominent in the red, reticular and raphe nuclei. Ultrastructural examination confirmed the suspicion of enhanced AChE activity. The significance of these findings and the novelty of the present procedure will be further discussed. (Aided by NIH grant NS - 12587-02S2).



TOPOGRAPHY OF THE NUCLEUS. PROTEIN INTERACTIONS. L.L. Higgins\* and K.R. Shelton. Dept. of Biochemistry and MCV/VCU Cancer Ctr., Med. Col. of Va., Richmond, Va. 23298

Major structural components of the avian erythrocyte nuclear envelope are oligomeric proteins. The two predominant polypeptides of the fraction are further distinguished by their ability to form homogeneous dimers. These details have been revealed by two-dimensional electrophoretic analysis of interpolypeptide disulfide bond cross-linked proteins. (Shelton, K.R. and Cochran, D.L., *Biochemistry*, 1978, in press).

The orientation of these polypeptides with respect to each other might be determined if methods were available to specifically cleave the cross-linked polypeptides, and to examine the products of the cleavage. We have found a previously unreported proteolytic activity endogenous to this fraction and have used it to pursue topographical studies.

The cleavage products of the 75 kd polypeptide are a 55 kd polypeptide and a 20 kd polypeptide, both of which can occur as homogeneous dimers. Mixed dimers in which one polypeptide chain is cleaved and the other is intact are also found.

The existence of homogeneous dimers of both cleavage fragments is consistent with a parallel alignment of the polypeptide chains in the dimeric state. Thus, examination of the cleavage fragments and the oligomeric species that are formed from the intact and fragmented polypeptides sheds light on the topographical arrangement of these polypeptides within the nucleus and increases our knowledge of nuclear structure at the molecular level.

ISOLATION OF THE COAT PROTEIN MESSENGER RNA FROM TURNIP YELLOW MOSAIC VIRUS. D. R. Lightfoot, H. N. Lightfoot\*, R. Clark\*, and P. R. Desjardins\*, Depts. of Biochemistry and Nutrition and of Veterinary Sciences, Va. Polytechnic Inst., Blacksburg, VA 24061 and Dept. of Plant Pathology, Univ. of Calif., Riverside, CA 92521.

RNA isolated by phenol extraction from capsids of Turnip Yellow Mosaic Virus (TYMV) sediments in sucrose density gradients at 23S. After gentle renaturation the 23S peak contains only 1/3 of the RNA, the remaining RNA forming several smaller distinct peaks. The same RNA size distribution was observed on denaturing, pH 3.5, 6 M urea, agarose gel electrophoresis. The smallest RNA component was purified by three rounds of sucrose density gradient centrifugation. It was found, by comparison to six standard RNAs, to have a mass of 273,000 Daltons. Spectral and melting analyses suggested that the RNA contains about 65% guanine plus cytosine and has a  $T_m$  of 57°C in 0.1 M  $[Na^+]$ . This small RNA was found to stimulate  $^{14}C$  valine incorporation 4 fold into the hot trichloroacetic acid precipitate of an *E. coli* cell-free protein synthesizing system. Incorporation was dependent on RNA concentration and persisted for up to one hour. Synthesized protein had a size of 20,000 Daltons when analyzed on 15% SDS polyacrylamide gel electrophoresis. This is the size of the viral coat protein. When using yeast valine tRNA synthetase, the RNA was charged to 62% mole / mole with valine. (Supported by Research Corporation).

PATTERN OF HORSE RADISH PEROXIDASE UPTAKE IN THE RAT BRAIN FOLLOWING INTRAVASCULAR INFUSION. R. L. Salisbury, R. J. Krieg, and H. R. Seibel, Dept. of Anatomy, Med. Coll. of Va.-Va. Commonwealth Univ., Richmond, Virginia 23298.

Intravascular injection of horseradish peroxidase (HRP) has been shown by Broadwell and Brightman (1976) to label certain neurons of the brainstem, hypothalamus, spinal cord, and autonomic ganglia. The technique employed single and multiple injections of up to 100mg of purified HRP into the mouse. The present study was designed to investigate whether neurons in the rat could be effectively labeled under conditions of prolonged exposure to a lower dose of HRP. Thirty-minute infusions of 25-75mg of HRP were performed via an indwelling atrial catheter in freely behaving rats (270-330g). Animals were anesthetized 2, 4, 6, 18, or 24 hours after HRP and perfused with modified Karnovsky's fixative. The brains were removed and HRP localized in frozen sections according to the procedure of Mesulam (1976). Circumventricular organs and the neurohypophysis were initially labeled with HRP, but cleared after 6 hours. Among hypothalamic areas, the supraoptic and paraventricular nuclei were found to be labeled after 18 hours. In contrast to previous findings in the mouse, no brainstem nuclei were labeled at any time. From these results we conclude that certain hypothalamic nuclei in the rat can be labeled after long-term infusion of a relatively low dose of HRP. Extensive labeling in other brain areas, however, appears to be dependent upon exposure to significantly higher dosage levels of HRP.

CATECHOLAMINE LEVELS AND SYNTHESIS RATES IN RAT BRAIN REGIONS AFTER HEAD INJURY. F.P. Huger\* and G.A. Patrick\*. Dept. of Pharmacology, Med. Col. of Va., Richmond, VA 23298

Unanesthetized male Sprague-Dawley rats were subjected to brain injury using an acceleration-deceleration device. Endogenous tyrosine, dopamine (DA) and norepinephrine (NE) were determined fluorometrically and catecholamine synthesis rates were determined by a radioisotopic method. These values were determined in four brain regions: cortex-striatum, midbrain-hypothalamus, medulla-pons and cerebellum. Neurochemical determinations were performed at 5, 15, 60 and 120 minutes post trauma. One group of rats at each time period was subjected to a sham drop procedure to control for the effects of stress in this model and some of the alterations seen can be attributed to stress. These changes include increases in tyrosine and decreases in NE levels in all brain areas and decreases in DA in the cortex-striatum. Head injury caused a significant increase in DA in the medulla-pons at 5 minutes after trauma and in the midbrain-hypothalamus at 15 and 60 minutes post trauma. NE synthesis rates in the cerebella of the traumatized animals at 120 minutes post trauma were significantly higher than in control and sham animals. (Supported in part by NIH Grant # NS-12587-01A1).

THE ISOLATION AND CHARACTERIZATION OF A C TYPE VIRUS FROM HVG MICE. S. Cross\*, R. Hard\*, J. Ruffolo, and C. O'Neal. Depts. of Pathology and Biophysics, Med. Col. of Va., Richmond, VA. 23298

Hard has described a Host Versus Graft (HVG) syndrome in mice produced by injecting spleen cells from a  $[T_6 \times RFM(+)] F_1$  cross back into the RFM (+) parental line. The resulting chimera has a number of pathologies including T(-) immunodeficiency, hyperimmunoglobulinemia, liver and renal lesions, plasmacytosis and under some conditions, tumors of the lymphatic system and liver. HVG mice usually die in about 30 days of membranous glomerulonephropathy presumably resulting from deposition of immune complexes of globulin and murine leukemia virus (MuLV) found in this system. The IgG<sub>1</sub> levels of these mice are elevated 29-72 times control values. Extensive work has been carried out to eliminate other possible murine viruses in the pathogenesis of this system including LDH and LCM virus, hepatitis virus, pneumonia virus, salivary gland virus, thymic virus and minute virus. MuLV has been isolated from this system and demonstrated to have appropriate immunological, morphological and density properties. Isolates from this system have been grown in quantity on SC-1 cells and purified by isopycnic sucrose density gradient centrifugation. The major component has a density of 1.66 and has the characteristic morphology of murine C type particles. These studies will be discussed in relation to future studies on this disease syndrome.

CORRELATION OF ELECTROANALGESIA AND INHIBITION OF LUTEINIZING HORMONE RELEASE IN RESPONSE TO STIMULATION OF PERIAQUEDUCTAL GRAY. A.R. Swajkowski\* and J.H. Johnson\*. Department of Anatomy, Medical College of Virginia, Richmond, Va. 23298

Injections of morphine into the midbrain produce analgesia and blockade of ovulation in rats. Stimulation of the midbrain has also been shown to produce these effects. The present study is an attempt to determine whether a single site of stimulation can mediate both effects. Adult female Sprague-Dawley rats were ovariectomized 28-32 days prior to stereotaxic implantation of bipolar stainless steel electrodes in both the periaqueductal gray and a distant site. Blood samples (100  $\mu$ l in duplicate) were collected through a cannula in the right jugular vein at 10 minute intervals for 3 hours. Stimulation of one brain site with a 10Hz presentation of balanced pulse pairs of 1-3mA intensity and 500sec duration with a 1000sec interval between pulses was carried out during the second hour. Blood was assayed for LH by double antibody radioimmunoassay. The experiment was repeated 4-7 days later with stimulation through the second electrode. Electroanalgesia was assessed using the tail flick method. In two cases with electrodes located in the ventral periaqueductal gray, stimulation resulted in both analgesia and decreased LH release. In 3 cases with electrodes in other mesencephalic or thalamic locations, stimulation neither decreased LH nor resulted in analgesia. These results indicate that the same regions of the periaqueductal gray may participate in both the control of LH secretion and in pain modulation.



CHANGES IN EEG ACTIVITY FOLLOWING ADMINISTRATION OF METHADONE IN FEMALE RATS. K.W. Waller\* and J.H. Johnson\*, Department of Anatomy, Medical College of Virginia, Richmond, VA 23298.

Methadone is a narcotic drug which is capable of binding to opiate receptors and blocking ovulation in the rat. Opiate receptors are located near the midbrain raphe and the basal forebrain is involved in initiating ovulation. This analysis was done to describe changes in spontaneous EEG activity recorded from these deep sites as well as from the surface of the parietal and frontal cortices of female Sprague-Dawley rats in response to methadone treatment previously shown to block ovulation. After recording EEG for 1 hour from the untreated animal, methadone (5mg/kg,sc) was injected three times at hourly intervals. EEG was recorded on magnetic tape for 3 min at 5 min intervals, from which 1-6 10-sec samples were chosen for computer analysis of autospectra. Isometric plots of autospectra vs time were prepared for visual observation, and statistical comparison of the power in 5Hz frequency bands from 1-25Hz was made. In each of 4 rats a significant increase in power was seen in the 1-5Hz EEG activity recorded from every electrode. A concomitant decrease in power was observed in 6-25Hz activity. These results indicate that systemic administration of methadone has profound effects on EEG activity recorded from diverse regions of the CNS. Such marked alterations in neural activity may be correlates of altered physiology including blockade of ovulation. However, the origin and specificity of these changes remain to be established.

## Section of Microbiology

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### STUDIES OF CITRATE-POSITIVE VARIANTS OF *ESCHERICHIA COLI*.

D. J. Ayers\* and S. M. McCowen, Dept. of Biology, Va. Commonwealth Univ., Richmond, VA 23284

Citrate-positive isolates of *E. coli* and spontaneous cit<sup>-</sup> revertants of each isolate were obtained from the Center for Disease Control. The ability of cit<sup>+</sup> strains to utilize citrate as a carbon source was confirmed in growth studies using citrate minimal salts medium (CMSM); revertants of each strain were unable to grow in CMSM. Agarose gel electrophoresis of lysates from cit<sup>+</sup> strains and spontaneous cit<sup>-</sup> revertants revealed the presence of one or more species of plasmid DNA in each strain. However, the plasmid contents of each isogenic pair were identical, providing evidence that the cit<sup>+</sup> trait is not plasmid linked. Moreover, transfer of the cit<sup>+</sup> characteristic into cit<sup>-</sup> recipients was not achieved in transformation experiments using plasmid DNA from cit<sup>+</sup> donors. Studies aimed at determining whether the cit<sup>+</sup> trait results from the acquisition of a citrate transport activity were conducted. Cells of cit<sup>+</sup> strains accumulated only low levels of <sup>14</sup>C(1,5) citrate and this uptake activity was present in cells that had been grown in the presence or absence of citrate. However, rapid and extensive respiration of <sup>14</sup>CO<sub>2</sub> by cell suspensions preceded any significant accumulation of labeled citrate carbon or its incorporation into TCA precipitable cell material. These results provide some evidence for partial metabolism of citrate prior to its uptake and subsequent metabolism. There is little evidence thus far for a citrate specific transport system unique to these cit<sup>+</sup> strains.

### ISOLATION AND CHARACTERIZATION OF *GLUCONOBACTER* PHAGE. C.A. Baker\*, and G. W. Claus, Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

This study was initiated in order to determine the frequency of *Gluconobacter* phage in the environment. Twenty samples of decaying apples were selected from one mid-western and three eastern States. Enrichment techniques were used that allowed development of acetic acid bacteria in all samples. *Gluconobacter* phage were isolated from 8 samples. According to the classification of Bradley (Bacteriol. Rev. 31:230, 1967), 13 phage examined so far had 3 structural types; 6 were Type A, 4 were Type B, and 3 were Type C. Type C phage had head diameters from 64-68nm with non-contractile tails from 20-28nm long. Type B phage had 60-80nm head diameters and flexible non-contractile tails from 320-400nm long. Some of these phage also had complex collars with fibrils. Most of the Type A phage had head diameters from 60-100nm and contractile tails 110-128nm long. One Type A phage had a head diameter of 170nm and a 136nm long tail with fibrils. This phage forms plaques on an isolate and on ATCC strain 621. Most of these phage appear temperate on *Gluconobacter* isolated from the same environment, but plaques often become more clear with subsequent transfers. These findings demonstrate that diverse types of *Gluconobacter* phage are commonly present in habitat materials. Future studies will determine what effect these phage have on oxidative characteristics of these industrially important bacteria.

IDENTIFICATION OF ELECTRON CARRIERS THAT REDUCE METRONIDAZOLE: A MECHANISM FOR THE ACTIVATION OF METRONIDAZOLE IN STRICT ANAEROBES. D. K. Blanchard\*, T. D. Wilkins\*, and J. S. Chen\*. Anaerobe Lab, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

Metronidazole is an effective antimicrobial agent against many anaerobes. It has been suggested that metronidazole has to be reduced (activated) to be effective and that ferredoxin is necessary for that activation.

An assay system was developed in which the reduction of metronidazole by an electron carrier could be continuously monitored. The flow of electrons in the assay using purified ferredoxin (Fd) and hydrogenase ( $H_2$ ase) from *Clostridium pasteurianum* is as such:  $H_2 \rightarrow H_2$ ase  $\rightarrow$  Fd  $\rightarrow$  metronidazole. *C. pasteurianum* flavodoxin also reduces metronidazole in this system. Both electron carriers have midpoint redox potentials in the range of the  $H_2$  electrode, about -400mV. Using this assay, a flavodoxin-like substance from *Bacteroides fragilis*, an anaerobe susceptible to metronidazole but which apparently lacks ferredoxin, was shown to reduce metronidazole. Also, a ferredoxin-like component from *Eubacterium lentum* reduces metronidazole. *E. lentum* is susceptible to metronidazole, but does not produce  $H_2$ .

It is proposed that other electron carriers with similar redox potentials will also reduce metronidazole. The presence of  $H_2$ ase does not seem necessary for activation, but can serve as a useful indicator for an organism's possible susceptibility to metronidazole.

FUNCTIONAL HETEROGENEITY OF *CORYNEBACTERIUM PARVUM* ACTIVATED MACROPHAGES IN TUMOR IMMUNITY.

M. Campbell\*, and G. Miller\*. Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298

*C. parvum* (CP) activated peritoneal macrophages (PM) are effective at inhibiting tumor cell growth in vitro. This cytostatic activity was found to be restricted to a subset of PM from CP treated rats. PM were harvested from Lewis rats and purified by adherence on collagen coated petri plates. PM were separated into 4 subclasses based on sedimentation properties in a discontinuous Ficoll gradient composed of 4%, 6%, 8% and 10% layers. Greater than 90% of the cells in each subclass were characterized as macrophages (M $\phi$ ) by morphology, latex phagocytosis, EA rosetting and nonspecific esterase activity. Cells from each subclass were tested for in vitro cytostatic activity against a syngeneic Moloney sarcoma tumor line (LM2). M $\phi$  and tumor cells were incubated together in microtiter wells and the incorporation of  $^{125}I$ iododeoxyuridine into LM2 was measured. M $\phi$  in the 10 and 8% bands were effective at inhibiting radiolabel uptake whereas M $\phi$  in the 4 and 6% bands had little cytostatic effects. Results suggest antitumor activity of CP activated PM is restricted to a subset of cells with properties resulting in their sedimentation in the most dense Ficoll layer. (Aided by ACS Grant IN-105B)

CHARACTERIZATION OF 2-DEOXYGLUCOSE UPTAKE BY NORMAL AND ANATIDAE HERPES VIRUS INFECTED DUCK FIBROBLASTS: EFFECTS OF PHOSPHONOACETATE. R. Gampen\* and J. C. Johnson, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Anatidae herpesvirus (AH) is the etiological agent of duck viral enteritis, a hemorrhagic, frequently fatal disease of ducks, geese and swans. In duck embryo fibroblast culture (DEF) the AH virus induces cell rounding, infrequent syncytia and perinuclear vacuolation 18 hours after infection followed by cell lysis. The virus-induced cytopathic effect can be inhibited by delayed application of phosphonoacetate (PAA) 24 hours post-infection. The incubation of low MOI infected cells in growth media containing 100 $\mu$ g/ml PAA results in an abortive infection in which areas of higher cell density or cellular debris are observed (opaque areas). The uptake of 2-deoxy-d-glucose (2-DOG) in normal subconfluent cells, AH-infected cells, PAA-treated, and AH infected - PAA treated cells was measured. Lineaveaver-Burk plot of the initial rate of 2-DOG uptake was not linear. The rate of transport of 2-DOG in AH-infected DEF increased 8-fold prior to cell lysis. The rate of 2-DOG transport in PAA treated cells was the same as found in control cells and in AH-infected-PAA treated DEF. The increased uptake in AH-infected cells may be due to the loss or modification of normal facilitated sugar transport. PAA inhibits both the AH-induced cytopathic effects and the higher rates of 2-DOG uptake.

AN ACTIN MESHWORK ASSOCIATED WITH ENDOCYTIC MEMBRANE IN FIBROBLASTS. Richard Ghadwick and Brian Storrer. Dept. of Biochemistry and Nutrition, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061

Phagocytosis of latex beads by Chinese hamster fibroblasts results in the perinuclear accumulation of latex. Extraction of the latex treated cells with the non-ionic detergent, triton X-100, fails to release the beads into the medium, although much of the cell is solubilized. The beads are retained in association with the triton insoluble cellular skeleton. Extraction of parallel latex treated cells with the ionic detergent, sodium dodecyl sulfate completely solubilizes the cell and releases the latex. Together these observations suggest the association of a triton insoluble protein meshwork with the latex phagosomes. Indirect immunofluorescent staining of triton treated cells indicates the presence of the contractile protein, actin, about each bead. Experiments are in progress to demonstrate the association of actin filaments with latex phagosomes by electron microscopy and to quantitate the amount of total cellular actin associated with the latex phagosomes by gel electrophoresis.

ANTI-TICK VACCINE DEVELOPMENT: POTENTIAL USE OF SALIVARY GLAND AND DIGESTIVE TRACT ANTIGENS. F.B. Clare, Jr. and S. B. Ackerman. Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23508

Numerous attempts by various research groups at producing anti-tick immunity have proven unsuccessful. Previous efforts have limited their choices of antigen material to either whole tick preparations or salivary secretions. The present study investigated the antigenic use of salivary gland and mid-gut components - potential targets for immune cells and/or serum ingested by feeding ticks (*Dermacentor variabilis*). Protein analysis by poly-acrylamide gel electrophoresis of salivary gland, mid-gut and whole tick preparations have been performed. Rabbit antiserum to saline extracts of whole ticks has been utilized to evaluate immunoprecipitation patterns in both double diffusion and immunoelectrophoresis assays. Protection experiments are in progress to determine the extent of immune resistance generated in rats to vaccination with mid-gut and whole tick extracts. Parameters such as tick feeding habits, mortality and fecundity are being examined.

EFFECT OF PYRAN ON HERPES SIMPLEX VIRUS (HSV) INFECTIONS. P.F. Cline\*, P.S. Morahan, M.C. Breinig\* and B.K. Murray. Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298

Systemic i.v. treatment of mice with the polyanionic immunomodulator pyran, 24 hr prior to virus inoculation, significantly protected mice from systemic (i.v.), vaginal or oral HSV infection. Pyran significantly reduced virus titers in the CNS and protected mice against mortality following i.v. HSV-2 infection. Pyran treated mice that survived infection had a lower incidence of detectable neutralizing antibody. However, the incidence of latent HSV-2 infection in the cervical-thoracic dorsal root ganglia (DRG) was not increased when compared with controls. Pyran treatment prior to vaginal HSV-2 infection inhibited virus replication in the genital tissues and decreased mortality. Very few untreated or pyran treated mice that survived infection showed either latent HSV-2 infection of the lumbar sacral DRG or a neutralizing antibody response.

Pyran treatment also decreased the maximum severity of lip lesions after oral HSV-1 infection. Pyran treated mice demonstrated a significantly lower incidence of antibody production than did control mice, although the incidence of latent HSV-1 infection in the trigeminal ganglia was not decreased. This, pyran treatment significantly protects mice against HSV disease but neither predisposes mice to development of latent HSV-2 infection nor decreases development of latent HSV-1 infection following oral inoculation. (Supported by VCU Grants-in-Aid, CA 16193, AI 05431, AI 70863 and DE 04700.



INHIBITION OF MLR REACTIVITY BY TUMOR-INDUCED SUPPRESSOR T CELLS. K. M. Connolly and K. D. Elgert. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Augmenting concentrations of macrophages ( $M\phi$ ) or their supernatants, failed to reverse T cell hyporeactivity in tumor-bearing mice (TBM). Serial passaging over nylon wool columns depleted TBM spleen cells of a mildly adherent tumor-induced suppressor cell, and restored mixed lymphocyte reaction (MLR) reactivity to the purified TBM T cell population. Extensively plated to remove  $M\phi$ , and characterized as a T cell by its anti-Thy 1 serum sensitivity, the suppressor T ( $T_S$ ) cell, when added back to normal or purified TBM T cells, abrogated all enhancing effects due to addition of  $M\phi$  or  $M\phi$  supernatants. Suppressor T cell inhibition was non-contact dependent, since  $T_S$  cell supernatants negated MLR activity in T cells treated with enhancing concentrations of  $M\phi$  supernatant. Thus it appears that tumor-induced T cell debilitation is a reversible phenomenon, mediated, not by  $M\phi$  but by soluble factor(s) from a non-phagocytic, mildly adherent, suppressor T cell.

ENHANCED AEROTOLERANCE OF *SPIRILLUM VOLUTANS*. W. H. Cover and N. R. Krieg. Dept. of Biology, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The obligate microaerophile *S. volutans* ordinarily grows best at 6%  $O_2$  in peptone-succinate (PS) broth and fails to grow at 21%  $O_2$ . However, when low levels of bisulfite are added, it can grow at 21%  $O_2$ . A combination of an iron salt (present in PS broth) and bisulfite has previously been shown to have superoxide dismutase (SOD) activity. Greatly increased aerotolerance of *S. volutans* can also be achieved by addition of bovine SOD, nor-epinephrine, or catalase to PS broth, or by substituting vitamin-free, salt-free acid-hydrolyzed casein for the peptone in PS broth.

*S. volutans* has never been cultured on solid agar media. However, colony formation has now been achieved on casein hydrolysate (CH) broth solidified with 1.3% carrageenan type I. Ordinarily growth occurs only at 6%  $O_2$ , but the addition of bisulfite permits growth to occur at 10%  $O_2$  and possibly higher  $O_2$  levels.

On the basis of these results and also previous studies of the microaerophile *Campylobacter fetus* in our laboratory, it is proposed that the occurrence of superoxide radicals and peroxide in culture media are responsible at least in part for the microaerophilic nature of these bacteria. It is also proposed that the agents which enhance aerotolerance do so by destroying these toxic forms of oxygen in the medium rather than by directly acting on the organisms.

BEWILDERING FUNGI OF THE VIRGINIA ENVIRONMENT. D.M. DIXON\* and H.J. Shadomy. Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298.

The Virginia environment has been shown to harbor a number of fungi which cause disease in man and animals. During an epidemiological investigation of the significance of woody plant material in the natural habitats of zoopathogenic fungi, a novel group of organisms was encountered. These were the dematiaceous (dark-colored) fungi identical to the etiologic agents of chromomycosis, mycetoma, and phaeohyphomycosis. Using an animal inoculation technique, 12 of 21 sites in rural Suffolk, Va. were positive for dematiaceous fungi including *Exophiala*, *Phialophora*, and *Cladosporium* spp. Subsequently, three methods were examined for effectiveness in recovering these organisms from nature in Williamsburg, Va. These included direct plating of processed samples onto selective media, inoculation of hamsters and inoculation of mice with subsequent plating of target organs on selective media. Hamster inoculation provided the greatest spectrum of dematiaceous fungi, followed by mouse inoculation and direct plating.

BACTERIOCIDAL ACTIVITIES OF METALS ON THE SURFACE OF ELECTRODES WITH AND WITHOUT MICROAMPERE ACTIVATION. S.S. Edwards and G. Colmano, Dept. Vet. Sci., VPI & SU, Blacksburg, VA 24061

Three stainless steel (ss: coated with stearates of Ag, Al, Au, Ba, Ca, Cr, Cu, Li, Ni, P, S, Sn, Sr) or other metal electrodes (Ag, Al, Au, Cu, Pt) 5.5 cm long, dipped (5 mm, marked on a vial) into a  $10^9$ , 24 hr. *S. aureus* culture (standardized spectrophotometrically) were used: 1) In cotton plugged test tubes, filled with broth. 2) By insertion through holes melted on the sides of plastic petri dishes. 3) In each of 7 ml serum vials with agar, or in 3 separate vials (2 bridged by a Cu wire), either by direct insertion into the agar or in agar wells (previously prepared with a 14 gauge needle), in which  $0.02$  ml  $10^5$  -  $10^8$  of bacteria was injected. One hour  $30 \mu A$  positive and negative direct current ( $30 \mu A \pm DC$ ) was applied between 2 pins (with no current pin as control) that were afterwards transferred to 5 or 10 ml broth, serially diluted, plated and colonies counted. The transferring and culturing started either after overnight incubation, or immediately after current application. After 12 - 18 - 24 hr incubation the growth around the agar on the pin surfaces was observed (with or without the pins in the agar). Reproducible counts were obtained with  $0.02$  ml of  $10^5$  -  $10^8$  bacteria in the wells. The different bacteriostatic activities of metals and combination of metals in films established definite responses of bacteria to metals with or without current ionization.

DETECTION OF AN INDUCIBLE MANNITOL-BINDING PROTEIN IN *PSEUDOMONAS AERUGINOSA*. Robert C. Eisenberg\* and P. V. Phibbs, Jr. Dept. of Microbiology, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298

*Pseudomonas aeruginosa* strain PAO catabolizes mannitol via inducible mannitol active transport (Mtr) and cytoplasmic mannitol dehydrogenase (MDH). Periplasmic extracts of cells were obtained using a 0.2M  $MgCl_2$ -osmotic shock procedure developed for isolating *P. aeruginosa* glucose binding protein (GBP) (Stinson et al., 1977, J. Bacteriol. 131:672). These periplasmic extracts contained mannitol binding protein (MBP) activity and apparent MBP production was co-regulated with Mtr. GBP and glycerol binding proteins were induced by growth of cells on glucose and glycerol respectively. Binding proteins were substrate specific since periplasmic extracts containing any one of these induced activities did not contain induced levels of the other two. Trace amounts of MDH activity were present in periplasmic extracts. Since MDH might contribute to apparent MBP activity, an  $(NH_4)_2SO_4$  fraction of cell extract was chromatographed on Sephacryl S-200. MDH and MBP activities were resolved and column fractions containing MDH did not exhibit detectable MBP activity. Over 97% of the total MBP or GBP was not released by the periplasmic extraction procedure, but the percent of total MBP or GBP was about 6-fold higher than the percent of total cytoplasmic glucose-6-P dehydrogenase activity in these periplasmic extracts.

DUALISTIC MODULATION OF SARCOMA-BEARING MICE T LYMPHOCYTE BLASTOGENESIS: MACROPHAGE ( $M\phi$ ) AND SUPPRESSOR T ( $T_S$ ) CELLS. K.D. Elgert, K.M. Connolly and W.L. Farrar\*. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Normal and tumor-bearing mice (TBM) spleen cells, were used in PHA, dinitrophenyl-bovine serum albumin (DNP-BSA; after contact sensitization with DNFB) and mixed lymphocyte reaction (MLR) assays to examine the regulatory modus operandi governing in vitro T cell proliferation. It appears that immunoregulation is mediated by  $M\phi$ , and/or  $T_S$  cells from the spleen and thymus of TBM (but not normal).  $T_S$  cells, mildly adherent to nylon wool, were sensitive to hydrocortisone and anti-Thy 1 serum. In admixture experiments, low concentrations  $T_S$  cells severely inhibited blastogenesis in all assays. Suppression was not contact dependent since  $T_S$  cell supernatants contained an inhibitor(s) which suppressed normal T cell DNA polymerase activity and PHA, DNP-BSA and MLR responses. Adoptive transfer of  $M\phi$  or  $T_S$  cells inhibited recipient PHA and DNP-BSA responsiveness.  $M\phi$ , served a dual, concentration dependent, immunoregulatory role. In all assay systems, high doses of  $M\phi$  caused inhibition. In low concentrations,  $M\phi$  augmented the response to soluble or histocompatibility antigens (but not mitogens).  $M\phi$  supernatants yielded a heat labile activator and a heat stable inhibitor, effective in regulating only MLR reactivity. It is postulated that TBM T cell debilitation is due to a physiological distinct  $T_S$  cell while  $M\phi$  regulation seems to be a concentration dependent mechanism.



A PRELIMINARY EXAMINATION OF COLIFORMS IN ESTUARINE SEDIMENTS. C. W. Erkenbrecher, Jr., Dept. Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

A paucity of information is available on the abundance and distribution of coliforms in estuarine sediments. As a result a study of the Lynnhaven estuary was undertaken. The ten permanent sampling sites that were chosen represented a spatial distribution from the inlet to the headwaters. Total and fecal coliforms, fecal streptococci, and total viable counts were monitored from water and sediment as were salinity, water temperature, and dissolved oxygen. Samples collected in triplicate revealed as much as a two log increase in total and fecal coliforms and fecal streptococci in the sediment as compared to the overlying waters. Spatial distribution of counts seem to correlate with salinity (lowest densities at the inlet site). These counts were well above the standard level of 14 fecal coliforms per 100 ml for shellfish growing waters in the six months studied. From FC:FS ratios, the source of pollution appeared to be indicative of runoff and showed no significant human origin. The idea of an indigenous benthic coliform community may be important in assessing water quality because the disturbance and resuspension of a significant number of these bacteria (and pathogens perhaps) into the water column may result in a threat to public health. These preliminary studies point to the need for more detailed microbiological examinations of sediments.

EXTRACTION AND ELECTROPHORETIC ANALYSIS OF VARIOUS ENZYMES OF *PODOSPORA ANSERINA*. Louise M. Erskine\*. Dept. of Biology, Randolph-Macon Woman's Col., Lynchburg, Va. 24503

Utilizing a single phosphate buffer system and extraction procedure, a wide range of enzymes was extracted from the tetraspore ascomycete *Podospora anserina* Niessl. Agar gel and acrylamide gel electrophoretic techniques were used to identify the following enzymes and isoenzymes: tyrosinase, laccases, esterases, peroxidase, alkaline phosphatases, acid phosphatase, amylase, leucine amino peptidase, and cytochrome oxidases.

SUPPRESSION OF IMMUNE BLASTOGENESIS IN TUMOR-BEARING MICE DURING CONTACT SENSITIVITY. W.L. Farrar\* and K.D. Elgert. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Sensitized lymphocytes from fibrosarcoma-bearing BALB/c mice, immunized with 2,4-dinitro-1, 5-difluorobenzene, demonstrated a progressive decrease in immune blastogenesis to the hapten-protein conjugate dinitrophenyl-bovine serum albumin (DNP-BSA). Hyporesponsiveness to DNP-BSA appears in the spleens but not lymph nodes of tumor-bearing mice (TBM). In admixture experiments, two distinct populations of TBM splenic suppressor cells were detected. Both were capable of inhibiting normal spleen cell antigen-induced blastogenesis. The addition of optimal concentrations of normal or TBM splenic macrophages ( $M\phi$ ) augmented the *in vitro* DNP-BSA responsiveness of normal primed spleen cells. At supraoptimal *in vitro* concentrations, however,  $M\phi$  greatly inhibited immune blastogenesis. Suppressor T cells were also detected in the spleens plus the thymuses of TBM. Suppressor T cell regulation was not contact dependent since their supernatants also impaired immune blastogenesis. This soluble factor(s) did not absorb to  $M\phi$ . The adoptive transfer of  $M\phi$  or suppressor T cells inhibited normal immune recipient DNP-BSA responsiveness. The collective data indicates that TBM hyporesponsiveness was due to the concomitant inhibitory influences of tumor-induced suppressor T cells and high concentrations of  $M\phi$ .

VARIATION OF THE LIVER COMPONENT IN AXENIC CULTURES OF *NAEGLERIA FOWLERI*. J. B. Haight\* and D. T. John. Dept. Microbiol., Va. Commonwealth Univ., Richmond, VA 23298.

Media used for cultivation of *N. fowleri* include those of Cerva, Chang, Balamuth, and Nelson. Growth of *N. fowleri* was compared in the four media under agitated and unagitated culture conditions. Flasks, each containing 25 ml of medium, were inoculated with  $10^4$  amebae/ml and incubated at 37 C. Coulter counts were made at 12 h intervals for 96 h of growth. Nelson medium was best for growing *N. fowleri* under either agitated or unagitated culture conditions. Under agitation, cell yield for Nelson medium (maximum of  $1.4 \times 10^6$  cells/ml) was about 10-fold greater than it was for the other media. The concentration of the liver digest component of Nelson medium was varied from 0 - 1% and growth compared. Increasing the liver concentration increased cell yield although the increased yield was not equivalent to the amount of liver added. A comparison of various liver preparations showed that Panmede liver digest and liver extract concentrate 1:20 supported greater cell yields than liver fraction 2, liver fraction L, or Oxoid liver infusion. Peptone or casein-containing compounds and yeast extract were substituted for liver digest in Nelson medium. Yeast extract was equivalent to liver digest in supporting growth. The other compounds, although unable to achieve cell yields similar to liver digest or yeast extract, were able to increase yields by at least one log unit of growth.

ISOLATION AND PARTIAL CHARACTERIZATION OF BACTERIOPHAGES AGAINST *BACILLUS SPHAERICUS*. J. Hedrick\* and A. Yousten\*. Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Seven lytic bacteriophages have been isolated from soil samples using 2 strains of *Bacillus sphaericus* as hosts. An additional phage, M, obtained from Dr. D. Tipper is also being characterized. The phages are divided into 4 groups based on their hosts and spectrum of activity. Spectrum of activity was determined by the spot lysate method using 41 strains of *B. sphaericus*. Group I consists of 3 phages; 1A, 1B, and 3; which attack one other strain in addition to their host *B. sphaericus* SSII-1. Group II consists of 3 phages; 2, 63, and 64; which attack 5 strains in addition to their host *B. sphaericus* SSII-1. Group III consists of phage 4, which attacks 4 strains in addition to its host *B. sphaericus* 1593-4. Group IV consists of phage M, which attacks only its host *B. sphaericus* P-1. Electron micrographs of the phages place them into 3 morphological groups. All have polyhedral heads. Group I and II have long flexible tails and collars. Group III has a very short tail and a collar. Group IV has a contractile tail and no collar. Thermal inactivation curves of the phages have also been determined.

PROTON TRANSLOCATION AND ACID TOLERANCE OF THE ACETIC ACID BACTERIUM *GLUCONOBACTER OXYDANS*. D. L. Heefner\* and G. W. Claus. Dept. of Biology, Va. Polytechnic Inst. & State Univ. Blacksburg, Virginia 24061

The genus *Gluconobacter* is characterized by an extremely active respiratory rate, the excretion of organic acids, and an unusual acid tolerance. When cells are grown in buffered medium containing glucose, the pH drops from 6.0 to 3.8, and they retain full viability. In unbuffered glucose medium, however, cells die rapidly when the pH reaches 3.2. Washed exponential phase (EXP) cells held at pH 3.8 in 0.15M NaCl retain viability for many hours but die rapidly at pH values of 3.2. This rapid cell death only occurs when NaCl is present. Electron microscopy, gel electrophoresis, and enzyme assays of cells held at pH 3.2 in 0.15M NaCl demonstrate amorphous intracellular material, loss of intracellular proteins and soluble enzyme activity. Hydrogen and sodium ion translocation experiments demonstrate a simultaneous  $H^+$  influx and  $Na^+$  efflux (antiport) when washed EXP cells are held at pH 3.2 in 0.15M NaCl. However, if an oxidizable substrate is added shortly after placing cells at pH 3.2 in 0.15M NaCl, there is a rapid expulsion of  $H^+$  from the cells. These actively respiring cells retain their structural integrity, their full complement of intracellular proteins, and remain fully viable. These data indicate that respiration by *Gluconobacter* is linked to  $H^+$  expulsion, and the speed of this process may be necessary to protect these cells in their acidic environment.



FIDELITY OF PROTEIN SYNTHESIS DURING tRNA-DEPENDENT PROTEIN SYNTHESIS IN VITRO. W.M. Holmes\*, G.W. Hatfield\*, and E. Goldman\*. Dept. of Med. Micro., Univ. Cal., Irvine, CA. 92717. \*Present address, Dept. Micro., Med. Col. of VA., Richmond, VA. 23219

Leu-tRNA<sup>Leu</sup> dependent protein synthesis has been examined in extracts of *E. coli* cells which have a temperature sensitive mutation in the Leucyl-tRNA synthetase, in order to assess the usefulness and fidelity of tRNA dependent systems for studying codon-anticodon interaction using natural mRNA. In the absence of added aminoacylated tRNA<sup>Leu</sup>, a significant amount of misreading occurs at leucine codons as judged by incorporation of methionine or tyrosine at a rate 15-30% of the amount of protein synthesized in samples reconstituted with several Leu-tRNA<sup>Leu</sup> isoaccepting species. Beyond this endogenous misreading level Leu tRNA<sup>Leu</sup> isoaccepting species but not Leu tRNA<sup>Arg</sup> permit read through the first leucine codon (CUC) suggesting that tRNA<sup>Leu</sup> respond to a CUX or two letter code using natural message.

HETEROLOGOUS GENETIC TRANSFORMATION IN STREPTOCOCCUS SANGUIS. C. L. Keeler\* and F. L. Macrina, Dept. of Microbiology, Med. College of VA., VA. Commonwealth Univ., Richmond, VA. 23298.

*Streptococcus faecalis* plasmid pAM81, 17Mdal in size and conferring Erythromycin (Em) resistance and Lincomycin (Lm) resistance, has been transferred via genetic transformation into the oral organism *Streptococcus sanguis* strain Challis. We have demonstrated maximum competency (uptake of exogenous plasmid DNA) in very early log phase cultures. Two types of transformants, phenotypically identical in their resistance to Em and Lm, have been recovered. The first type, as represented by *S. sanguis* strain V480, has a 17Mdal plasmid which upon continued growth in Em is converted into a heterogeneous population of 17Mdal and 34Mdal plasmids. The 34 Mdal plasmid is thought to represent a dimeric form of the pAM81 plasmid. The second type of transformant, represented by *S. sanguis* strain V486, has only the 34Mdal plasmid present upon initial isolation. *S. sanguis* strain Challis was transformed to Em and Lm resistance at a 100-fold greater frequency using the dimeric form of the pAM81 plasmid found in *S. sanguis* strain V486 than with the 17Mdal monomeric form of pAM81 present in *S. faecalis* or in *S. sanguis* strain V480. This apparent size-related phenomenon is currently under investigation and could be used to elicit transformation of small nontransformable plasmids once their sizes had been increased either *in vivo* or by *in vitro* methods. (Supported by USPHS grant DE04224).

RELATEDNESS OF MOSQUITO PATHOGENIC AND NON-PATHOGENIC STRAINS OF *BACILLUS SPHAERICUS*. V. Krych\*, J. Johnson\*, and A. Yousten\*. Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The cells of certain strains of *Bacillus sphaericus* are toxic when ingested by mosquito larvae. The taxonomic relationship of the toxic strains to non-toxic strains of *B. sphaericus* and to other species of bacteria forming spherical spores which distend the sporangia is unclear. Examination of a number of phenotypic characters revealed none peculiar to the pathogens except mosquito pathogenicity itself. The G+C content of the DNA of both pathogens and non-pathogens was 34-37 moles % (by T<sub>m</sub>). However, examination of DNA homologies revealed that the pathogens constitute a rather distinct group having little homology to the type strain of the species. Three major homology groups have been identified among the pathogenic and non-pathogenic strains of *B. sphaericus*. Several strains do not fit into these three homology groups and additional groups may yet be identified.

A NOVEL PYRIDINE NUCLEOTIDE-LINKED OXIDOREDUCTASE FOR SUGAR NUCLEOTIDES AND SUGAR PHOSPHATES IN MUCOID *PSEUDOMONAS AERUGINOSA*. J.S. Karns\*, P.V. Phibbs, Jr. and F.L. Macrina, Dept. of Microbiol., Va. Comm. Univ., Richmond, VA 23298

*Pseudomonas aeruginosa* encapsulated with alginate acid are frequently isolated from patients with cystic fibrosis. The soluble fraction of crude extract of mucoid strain V209, was found to contain NAD-linked GDP-mannose dehydrogenase activity, an enzyme that may serve in alginate biosynthesis. DEAE-cellulose column chromatography resulted in a 10-fold purification of this activity. The same DEAE-purified preparation also catalyzed the reduction of NAD when mannose-6-P, fructose-6-P, fructose-1-P, GDP-glucose and UDP-glucose were presented as substrates. Glucose-6-P, mannose-1-P, mannose and UDP-mannose were ineffective substrates. All these activities were: specific for NAD as cofactor; coeluted in DEAE column chromatography; and produced an identical band in non-denaturing polyacrylamide gels stained for dehydrogenase activity. The GDP-mannose, M-6-P and F-6-P dependent activities displayed identical denaturation kinetics at 56°C and 60°C; displayed an apparent K<sub>m</sub> of 0.23mM for NAD; and coeluted from Sephadex G-200 (the other activities were not tested for these parameters). The apparent K<sub>m</sub> was 0.18mM for GDP-mannose, 0.12mM for GDP-glucose and 0.37mM for M-6-P. The GDP-mannose, M-6-P and UDP-glucose activities displayed a broad pH optimum centered around pH 8.6. These observations indicate that a single enzyme is capable of oxidizing a number of nucleotide sugars and sugar phosphates. Products of these reactions have not been identified.

INOCULUM SIZE AND pH AFFECTING THE GROWTH OF *NAEGLERIA*. S. M. Koch\*, R. R. Weik and D. T. John. Dept. Microbiol., Va. Commonwealth Univ., Richmond, VA 23298.

*Naegleria fowleri* (LEE) and *N. gruberi* (EGB) were cultured with agitation in 125-ml Erlenmeyer flasks in 25 ml of Nelson medium (37 C, pH 5.5) and Balamuth hemin medium (28 C, pH 6.5), respectively. Flasks inoculated with 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup> and 10<sup>6</sup> amebae/ml had at 96 hr culture age a yield of 1.3 x 10<sup>5</sup>, 4.3 x 10<sup>5</sup>, 9.6 x 10<sup>5</sup> and 2.3 x 10<sup>6</sup> amebae/ml, respectively, for *N. fowleri* and 1.5 x 10<sup>5</sup>, 6.4 x 10<sup>5</sup>, 1.3 x 10<sup>6</sup> and 2.3 x 10<sup>6</sup> amebae/ml for *N. gruberi*. Addition of serum or hemin at 48 hr culture age to cultures inoculated at 10<sup>2</sup> amebae/ml produced a dramatic increase in growth. Such cultures inoculated at 10<sup>2</sup> and others at 10<sup>4</sup> amebae/ml yielded at 100 hr 1.2 x 10<sup>6</sup> and 1.4 x 10<sup>6</sup> amebae/ml, respectively, for *N. fowleri* and 2.6 x 10<sup>6</sup> and 1.9 x 10<sup>6</sup> amebae/ml for *N. gruberi*. At 6 hr intervals the pH of the culture medium was adjusted to 5.5 for *N. fowleri* and 6.5 for *N. gruberi* with no apparent change in growth. By increasing the phosphate buffer from 2 to 20 mM, the pH rose more slowly; however, growth of *N. fowleri* was substantially reduced and *N. gruberi* growth was only slightly reduced. These results indicate that a minimum inoculum is not required to initiate growth, depletion of serum and hemin may limit growth, pH changes do not limit growth, and cell yields greater than 10<sup>6</sup> amebae/ml can be achieved regardless of inoculum size.

MULTIPLE PLASMID CONTAINING *E. COLI*: A SIMPLE METHOD FOR PREPARING PLASMID REFERENCE MOLECULES. F. L. Macrina, K. R. Jones\*, D. J. Kopecko\*, D. Ayers\* and S. M. McCowen. Depts. of Microbiology and Biology, Va. Commonwealth Univ., Richmond, and Walter Reed Army Institute of Research, Washington, D.C.

Preparation of plasmid size reference molecules for use as electrophoretic standards is limited by the necessity of utilizing several bacterial strains, each containing a single molecular species, in order to obtain a full complement of sizes. We recently analyzed a clinical isolate of *Escherichia coli*, designated V517 in our laboratory, that contains multiple plasmids of 8 distinct sizes. Using both agarose gel electrophoresis and contour length measurements of open circular plasmid molecules photographed in the electron microscope, molecular size values have been computed for each of the plasmids found in V517. The sizes of the plasmids, designated pVA517A - pVA517H, are: 35.8 x 10<sup>6</sup> (35.8 Mdal), 4.8 Mdal, 3.7 Mdal, 3.4 Mdal, 2.6 Mdal, 2.0 Mdal, 1.8 Mdal and 1.4 Mdal. No phenotypic function has been ascribed to any of the plasmids found in V517. Qualitative and quantitative plasmid isolation from V517 is highly reproducible making it a convenient single source of a range of covalently closed circular plasmid molecules useful as references in agarose gel electrophoresis. (Supported by USPHS grant DE 04224 and NSF grant PCM 77-00858.)



THE ROLE OF METABOLISM IN DIMETHYLNITROSAMINE INDUCED MUTAGENICITY. C.J. Magiera\*, T.L. Young\*, A.N. Tucker\*. and T. Tang. Dept. Pharmacology and Dept. Microbiology, Med. Col. of Va., Richmond, Va. 23298.

The carcinogen dimethylnitrosamine (DMN) is mutagenic to the bacterium *Salmonella typhimurium*, strain TA 100, only when it is activated by microsomal enzymes. In the present study, we used liver homogenates from C3H mice as a source of these activating enzymes and investigated the effects of polychlorinated biphenyl (PCB) pretreatment on demethylation and mutagenicity of DMN. Two different demethylating enzymes could be distinguished, as characterized by their relative affinities for the substrate, and both of these enzymes were induced by the PCB pretreatment. Activity of the high affinity enzyme ( $K_m$  of 0.5 mM, assayed at 4 mM DMN) was increased three-fold by PCB pretreatment, and activity of the low affinity enzyme ( $K_m$  of 66 mM, assayed at 200 mM DMN) was increased four-fold by PCB pretreatment. Mutagenicity of DMN at 4 mM was increased two-fold by PCB pretreatment, whereas mutagenicity of DMN at 200 mM was increased thirty-fold. All of the PCB-induced mutagenicity observed at 200 mM DMN can not be accounted for by DMN demethylase activity.

EFFECTS OF BACTERIAL ENDOTOXIN ON MALIC DEHYDROGENASE ACTIVITIES IN PRIMARY CULTURES AND FRACTIONS OF MOUSE LIVER. A. L. McGivney\* and S. G. Bradley. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, Va. 23298.

The molecular bases for the toxicity of bacterial endotoxin (lipopolysaccharide, LPS) are not known. We have examined the effect of LPS on the activities of selected lysosomal and mitochondrial enzymes of primary mouse liver cells. A Westphal preparation of *Escherichia coli* 0127: B8 LPS at 10  $\mu$ g/ml incubated with primary liver cells caused, within 4h, a slight elevation in activities of  $\beta$ -glucuronidase and acid phosphatase, two lysosomal enzymes. However, within 2h a significant two-fold decrease in malic dehydrogenase and succinic dehydrogenase activities was seen in the mitochondrial fraction of LPS treated primary liver cells. This mitochondrial enzyme change was progressive with time and concentration of LPS. These whole liver cell effects were then correlated with the leakage of malic dehydrogenase from isolated mitochondrial fractions treated with LPS. An increase in specific activity of malic dehydrogenase in the incubation medium of LPS treated mitochondrial fractions corresponded to an increase in activity of specifically stained malic dehydrogenase in non-denaturing polyacrylamide gels. The effects of LPS on the mitochondrial fraction were time and concentration dependent and correlated with LPS induced high amplitude mitochondrial swelling. These data suggest that LPS, by interacting with the mitochondrial membrane, may be perturbing the intactness of mitochondrial membrane function.

METHANE FORMATION FROM GIANT KELP AND KELP CONSTITUENTS BY AN ANAEROBIC MICROBIAL FOOD CHAIN. C. J. McIntyre and J. G. Ferry, VPI & SU, Blacksburg, Va.

Marine biomass has significant potential as a renewable source of energy (i.e., methane). To date, there is no information on the feasibility of using cultures of a marine anaerobic food chain which degrades kelp to methane. The original inoculum was collected anaerobically from sediment situated below a bed of *Macrocystis pyrifera*, off the coast of southern California. The cultures have been maintained strictly anaerobic under 80% nitrogen/20% CO<sub>2</sub> by the Hungate technique. Twenty per cent of each culture is replaced bimonthly with an artificial seawater medium which contains one of the following substrates (per cent final concentration in the enrichments): sodium alginate, .01% and .02%; mannitol, .01% and .02%; ground stem, .01% and .02%; and ground leaves, .01% and .02%. There is an 80-85% conversion of substrate to methane, indicating a food chain is present which contains the organisms necessary to degrade most of the kelp components. Precipitation of iron sulfide in the sediment and a strong odor of hydrogen sulfide suggest an active population of sulfate-reducing bacteria. The enrichments contain approximately 40% vibrios, 35% short, wide rods, and 15% very long, slender rods. There are also shorter, slender rods present. The concentration of accumulated methane reaches a maximum six to eight days after addition of substrate. Attempts to detect volatile fatty acid intermediates using a gas chromatograph equipped with a flame ionization detector have been unsuccessful, indicating that, if produced, the intermediates are rapidly consumed. We are applying more sensitive techniques for detection of these intermediates. Accumulation of hydrogen has been observed in gas samples taken two to eight hours after addition of substrate. This hydrogen quickly disappears, with the simultaneous appearance of methane. From this food chain we have obtained highly enriched cultures of hydrogen-oxidizing, carbon dioxide reducing methanogens. Visual examination of the cultures shows ninety per cent short rods, but a vibrio form is present which is not eliminated by omission of sulfate from the medium.

MANNITOL INDUCED FRUCTOKINASE IN *PSEUDOMONAS AERUGINOSA*. C.G. McNamee\* and P. V. Phibbs, Jr., Dept. of Microbiol., Va. Commonwealth Univ., Richmond, Va. 23298.

Growth of *Pseudomonas aeruginosa* PAO in the presence of mannitol (but not fructose) causes induction of soluble fructokinase (FK) (EC 2.7.1.4) activity. Cell extracts also contain independently inducible glucokinase (GK) activity that elutes closely with FK from Sephadex G-200. Previously described pyruvate carboxylase-deficient mutant PFB-14 was found also to be deficient in inducible GK activity but retained mannitol induced FK and mannitol dehydrogenase (MDH). FK from PFB-14 was partially purified and resolved from MDH by Sephacryl S-200 column chromatography. The pooled, concentrated FK-containing fractions were free of detectable GK activity. The FK preparation was more stable when stored at either 4°C or -68°C but activity was lost rapidly at -20°C. FK was saturable with respect to fructose concentration (apparent  $K_m$  of 0.9 mM) although activity was strongly inhibited by concentrations above 2 mM. ATP was an effective phosphoryl donor in the presence of Mg<sup>++</sup> or Mn<sup>++</sup>; GTP and CTP were less effective and phosphoenolpyruvate was ineffective. FK activity was linear with respect to extract protein concentration and maximum specific activity was observed at pH 8.4 in glycyl-glycine buffer. Radiochromatographic analysis identified the FK reaction product to be fructose-6-P which was quantitatively converted to 6-phosphogluconate upon the addition of phosphoglucoisomerase, glucose-6-P dehydrogenase and NADP.

EFFECTS OF PABA UPON THE POLYPHENOLOXIDASES OF THE TETRASPORE ASCOMYCETE *PODOSPORA ANSERINA* NIESSL. Katherine A. Montague\*. Dept. of Biology, Randolph-Macon Woman's Col., Lynchburg, Va. 24503

p-Aminobenzoic acid has been shown to affect sexual differentiation in *Podospora anserina* Niessl, causing an inhibition of perithecial development and a stimulation of anteridial formation at concentrations of 5.0 x 10<sup>-4</sup>M in solid medium.

Since the laccases and tyrosinases of this and related organisms have been implicated in sexual differentiation, the effect of PABA upon the activities of these enzymes was examined.

In tests in which dopachrome accumulation was monitored spectrophotometrically, PABA was found to produce noncompetitive inhibition of tyrosinase activity. While PABA had no effect upon the reaction rate of laccase, increasing concentrations of PABA did cause an apparent increase in the final amount of product formed. Electrophoretic studies strongly suggest that PABA is inhibiting polymerization of product to melanin.

IN VITRO RESTRICTION OF HERPES SIMPLEX VIRUS (HSV) BY MACROPHAGES (MØ). S.S. Morse\*, M.B. McGeorge\* & P.S. Morahan. Dept. of Microbiology, Med. Coll. of Va., Richmond, Va.

Peritoneal MØ from BALB/c mice inoculated with *C. parvum* or infected with HSV inhibited the growth of HSV in infected susceptible cells (extrinsic antiviral activity). When cocultivated with the cells (MØ:cell ratio ca. 2:1), which were previously infected with HSV, the MØ suppressed virus plaque formation by ≥90% and reduced HSV yield by 2-3 log<sub>10</sub>. Heat-killed HSV was somewhat less effective in eliciting the MØ activity than live HSV. Normal MØ had virtually no effect. The activity peaked at days 3-4 post infection and then waned. The MØ-mediated antiviral activity was not specific for species (protecting both infected VERO cells and mouse embryo fibroblasts) or virus (protecting cells against both HSV and vesicular stomatitis virus).

Supernatants from the active (*C. parvum*- or HSV-elicited) MØ did not directly inactivate virus when incubated with HSV for up to 4 hours. The supernatants also appeared unable to transfer antiviral activity to normal MØ when incubated with normal MØ for up to 48 hours. Further studies to define the mechanism of the MØ-mediated antiviral activity are underway.

The MØ antiviral activity was confirmed *in vivo* by MØ depletion. Intraperitoneal injection of silica, trypan blue or dextran sulfate, agents which inhibit MØ function, decreased the resistance of mice to HSV infection 10-100 fold. (Supported by NIH AI 07086 and AI 70863.)



INITIAL CHARACTERIZATION OF A NEWLY ISOLATED PHAGE (GW 6210) FOR GLUCONOBACTER OXYDANS. P.J. Pamperl\* and G.W. Claus. Biology Dept., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Baker and Claus recently isolated the Glucunobacter phage GW 6210 and found that it infected ATCC strain 621 of G. oxydans. This phage possesses polygonal heads and contractile tails; therefore, it can be morphologically placed into Bradley's Group A and tentatively placed in the virus family Myoviridae. Our intensive electron microscopic study shows this phage to have a polygonal head, collar, tail sheath, baseplate, and tail pins. This phage is primarily unusual because of its large size. Using Tobacco Mosaic Virus as an internal calibration standard, we found that the phage head was 170 nm in diameter and the tail was 136 nm long and 34 nm wide. Standard error calculated from the internal standard was  $\pm 9.0$  nm. Therefore, this appears to be the second largest bacteriophage ever reported. Initially, the phage preparation seemed to consist of two plaque types: a small clear plaque having a  $0.3 \pm 0.1$  mm diameter surrounded by a large turbid region that was  $3.5 \pm 0.7$  mm wide, and a small turbid plaque that varied greatly in size ( $1.4 \pm 0.8$  mm). However, present data indicate that these represent size variations of a single plaque type. Preliminary data from cesium chloride density gradient centrifugation shows this phage to have a density of about  $1.50 \text{ g/cm}^3$ . Future work will emphasize the nucleic acid type and degree of strandedness and the host range of this unusual phage.

CHARACTERISTICS OF ORAL HERPES SIMPLEX VIRUS INFECTION IN MICE USING AN IMMUNO-PEROXIDASE STAINING TECHNIQUE. W. J. Payne, Jr.\* and B. K. Murray. Dept. of Microbiology, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298

The immuno-peroxidase staining procedure combines the specificity of the antibody-antigen reaction with the sensitivity of an enzyme reaction. A section (6  $\mu\text{m}$ ) of tissue is mounted on a glass slide. The section is sequentially reacted with rabbit anti-HSV serum, goat anti-rabbit IgG serum and a complex of peroxidase, rabbit anti-peroxidase (PAP). These reagents form a complex with the virus antigens, and the complex is visualized by an enzymatic oxidation of a chromophore such as 3,3'-diaminobenzidine.

Six to eight week old Balb/c mice were infected by swabbing a virus inoculum on an abraded lip. Several different strains of HSV were used and their respective effects are compared. The lip, both trigeminal ganglia and the brain were removed at different times following inoculation. The tissues were fixed in 2% formalin with 0.1M sodium cacodylate buffer, pH 7.6. The tissues were processed in a standard technique and embedded in paraffin for obtaining paraffin sections. Virus antigens and virus induced cytopathic effects were found in tissues with high titers of infectious virus. Hematoxylin and eosin stains of tissue sections were used as a comparative tool. This work was supported by a NIDR grant DE 04700.

CHARACTERIZATION OF TWO DISTINCT POPULATIONS OF PRECURSORS TO ANTIBODY FORMING CELLS. D.L. Pitts\*, J.G. Tew, G.A. Miller\*, and E.J. Greene\*. Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298.

Previous studies from this laboratory using lymphocyte cell cultures prepared from the lymph nodes of human serum albumin (HSA) primed rabbits often produced two distinct peaks of antibody. Precursors to late antibody forming cells (192-240 hours in culture) were much more sensitive to specific antigen (HSA) than precursors to AFC of the early response (96-144 hours in culture). Precursors to early AFC were much more susceptible to feedback inhibition by passive specific antibody when added at culture initiation than precursors of late AFC. The late response could even be enhanced by specific antibody when administered at 96 hr in culture. Removal of phagocytic cells from cell suspensions at culture initiation by the carbonyl iron method resulted in increased antibody mediated suppression for both the early and late responses with the early response being more suppressed than the late. These studies suggest that the precursors to antibody producing cells during the early and late responses were qualitatively different in their interaction with specific antigen and antibody. (Supported in part by USPHS Grant No. AI-11101 and USPHS Career Development Award No. K4A10008A).

INITIAL CHARACTERIZATION OF TRANSCRIPTION IN BOVINE PARVOVIRUS-INFECTED CELLS. J. T. Patton, E. R. Stout, and R. C. Bates, Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Transcription of the bovine parvovirus (BPV) genome was studied in nuclei isolated from synchronized bovine fetal spleen cells. Endogenous RNA polymerase activities were measured by incorporation of  $^3\text{H}$ -UTP into acid precipitable material. RNA polymerase I, II, and III activities were assayed at two hour intervals through 16 hr p.i. and differentiated on the basis of their sensitivity to  $\alpha$ -amanitin and salt concentration. RNA polymerase II activity in infected nuclei was slightly elevated (<15%) during 8-12 hr p.i. as compared to mock-infected nuclei while RNA polymerase I and III activities were approximately the same in mock- and BPV-infected nuclei. However, the salt optimum for RNA polymerase II was the same in both infected and mock-infected nuclei (0.09 M  $(\text{NH}_4)_2\text{SO}_4$ ).

Nucleoprotein complexes (NPC) with associated RNA polymerase activity were isolated from BPV-infected nuclei by lysis with sarkosyl. Chromatography on Bio-Gel A5M and hydroxyapatite columns showed that the NPC consists of dsDNA and ssRNA and can be detected in infected nuclei by 4 hr. p.i. Based upon hybridization to virion DNA, the complexes were determined to be of viral origin. The RNA polymerase activity associated with the NPC was inhibited by 100% and 95% with actinomycin D (1  $\mu\text{g/ml}$ ) and  $\alpha$ -amanitin (1  $\mu\text{g/ml}$ ), respectively, indicating that the complexes are transcribed by RNA polymerase II.

A FLUORESCENT ANTIBODY STAINING TECHNIQUE FOR ENUMERATING THIOBACILLUS FERROOXIDANS IN ACID MINE DRAINAGE WATERS. K. Pham\* and J. Gates. Department of Biology, Virginia Commonwealth University, Richmond, VA 23284

Thiobacillus ferrooxidans is believed to be responsible for the oxidation of ferrous ion at low pH, the rate limiting step in the oxidation of pyrite ores and subsequent formation of acid mine drainage (AMD). It has been suggested that efforts to control this environmental problem include procedures that would inhibit this bacterium. At present, a "most probable number" (MPN) procedure, requiring a minimum of 10 days, is used to enumerate this microorganism in natural waters. If control of AMD through inhibition of T. ferrooxidans is to be feasible, it will be necessary to develop a more rapid method to detect population levels and thereby determine appropriate times to apply control measures.

An indirect fluorescent antibody staining technique (FA) using 0.4  $\mu\text{m}$  polycarbonate type filters was developed for this purpose, providing results in a few hours. Artificial AMD samples containing known numbers of T. ferrooxidans were tested using the FA and MPN procedures. The FA procedure more closely approximated expected numbers. The MPN procedure was found to be excessively conservative, indicating only 3-23% of the cells detected via FA.

MECHANISM OF INHIBITION OF NAEGLERIA FOWLERI PROLIFERATION BY  $\Delta^9$ TETRAHYDROCANNABINOL (THC). H.L. PRINGLE\* and S.G. BRADLEY. Dept. of Micro., Med. Col. of Va., Richmond, Virginia 23219

Cannabinoids have diverse biological effects including anti-microbial, anti-tumor, immunosuppressant, and psychotomimetic activity. The mechanism of action of the cannabinoids is not known. Cannabinoids have been shown to inhibit the proliferation of Naegleria fowleri in vitro. The inhibition of N. fowleri growth in vitro coincided with the inhibition of uptake of  $^{14}\text{C}$  labeled adenine, uridine, thymidine, leucine by amebae.  $\Delta^9$  THC at 10  $\mu\text{g/ml}$  markedly inhibited the uptake of labeled metabolites. Synthesis of DNA, RNA, and protein was impaired during the same period, indicating that the effects of  $\Delta^9$  THC were on a site common to each of these pathways. The contribution of selected functional groups of the cannabinoid molecule on its anti-naeglerial activity was assessed. The hydroxyl group of the phenolic ring contributed to the anti-naeglerial activity of the molecule. The integrity of the pyran ring was not essential; opening the pyran ring failed to alter the anti-naeglerial activity. Removal of existing or addition of new methyl groups to the pyran or cyclohexamide ring failed to alter the anti-naeglerial activity nor did unsaturation of the cyclohexamide ring. Our data indicate that DNA, RNA, and protein synthesis are inhibited secondarily and that the primary vulnerable locus involves a reaction or process required for synthesis of these macromolecules.



ENHANCED RESPONSIVENESS OF LYMPHOCYTES FROM PERIODONTALLY DISEASED PATIENTS TO BACTERIAL ANTIGENS AND PHYTOHEM-AGGLUTININ. Patricia L. Rice\*, John G. Tew, and Glenn A. Miller\*, Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298.

It has been postulated that the immunologic response of the host to dental plaque antigens is responsible for the pathogenesis of periodontal disease. If this is true, diseased patients should respond immunologically to plaque antigens in vitro. To test this, the response of patients with severe periodontitis was compared to that of normal controls using blast transformation of peripheral blood lymphocytes (PBL) as a correlate of cell-mediated immunity. Study participants were 18-30 years of age and evaluated to be free of other systemic diseases. PBL were cultured in the presence of cell wall antigens from typical plaque organisms and blast formation was monitored by  $^3\text{H}$ -thymidine uptake. Increased responsiveness of diseased patients over controls was obtained with *Actinomyces naeslundii*, *Bacteroides melaninogenicus*, *Fusobacterium nucleatum*, *F. polymorphum*, *Leptotrichia buccalis*, and phytohemagglutinin (non-specific mitogen). The response to *A. viscosus*, *Streptococcus sanguis*, *Veillonella alcalescens* and *Escherichia coli* (non-plaque organism) tends to show no difference. These results support the concept that immunologic responses of the host to plaque antigens contribute to the development of severe periodontitis.

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CHARACTERIZATION OF BOVINE PARVOVIRUS (BPV) DNA. A. K. Saemundsen\* and R. C. Bates. Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

The best characterized of the autonomous parvoviruses are those of rodent origin. All contain linear single-stranded DNA of about  $1.7 \times 10^6$  daltons with "hairpins" at the 3' and 5' ends. In this study we have examined BPV, a non-rodent parvovirus, which was purified from infected bovine cells by centrifugation through a sucrose-CsCl gradient. The virion DNA was released from the capsids by alkali treatment and chromatographed on hydroxyapatite. Viral DNA eluted from the column at a sodium phosphate concentration of 0.17 M, intermediate between single- and double-stranded DNA markers. BPV DNA had a buoyant density of  $1.72 \text{ g/cm}^3$  in neutral CsCl and a sedimentation coefficient of 16 S in alkaline sucrose, as determined by cosedimentation with adeno-associated virus-2 DNA. The molecular weight of BPV DNA was, thus, estimated to be  $1.5\text{--}1.7 \times 10^6$  daltons. The viral DNA was 85% resistant to digestion with exonuclease I, but 95% susceptible to S1 endonuclease. These results indicate that the properties of BPV DNA are very similar to those described for other autonomous parvoviruses.

A minor fraction of the DNA, released from the virions, eluted from hydroxyapatite in the position of double-stranded DNA. The nature of this viral DNA is under investigation.

7- $\alpha$ -DEHYDROXYLATION OF CHOLIC AND CHENODEOXYCHOLIC ACID BY *CLOSTRIDIUM LEPTUM* V.P.I. 10900. E. J. Stellwag\* and P. B. Hylemon. Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298.

The rate of 7- $\alpha$ -dehydroxylation of primary bile acids was quantitatively measured radiochromatographically in anaerobically washed whole cells of *C. leptum*. The pH optimum for the 7- $\alpha$ -dehydroxylation of both cholic and chenodeoxycholic acid was 6.5 to 7.0. Hyperbolic substrate saturation kinetics were observed for the 7- $\alpha$ -dehydroxylation of cholic and chenodeoxycholic acid. However, cholic acid  $K_m$  (0.37  $\mu\text{M}$ ) and  $V$  (200 nmoles/h/mg protein) values for 7- $\alpha$ -dehydroxylase activity varied significantly from chenodeoxycholic acid  $K_m$  (0.18  $\mu\text{M}$ ) and  $V$  (50 nmoles/h/mg protein). Enzymatic activity was not detected using glycine and taurine conjugated primary bile acids, ursodeoxycholic, cholic acid methyl ester or hyocholic acid as substrates. The 7- $\alpha$ -dehydroxylation of both cholic and chenodeoxycholic acid was inhibited by molecular oxygen, cell lysis, and the metabolic inhibitors 2, 4-dinitrophenol (2,4-DNP),  $\text{N,N}'$ -dicyclohexylcarbodiimide (DCCD) or carbonylcyanide- $\text{M}$ -chlorophenyl hydrazone (CCCP).

The levels of 7- $\alpha$ -dehydroxylating bacteria in fecal samples ranged from approximately  $10^4$  to  $10^6$  viable cells/gram wet weight feces.

DEVELOPMENTAL PATHWAY SELECTION IN A CILIATE PROTOZOON. John J. Ruffolo, Jr. Dept. of Biophysics, Med. Col. of Va., Richmond, Va. 23298.

The ciliate protozoan *Euplotes* is a unicellular eukaryote. The basic developmental pathway of *Euplotes* is the cell division cycle, within which we can distinguish the growth cycle, namely the progress of nutritional and metabolic processes to synthesize cellular molecules and structures, and the cell cycle, namely the sequence of nuclear DNA replication followed by cell division during cell proliferation. In ciliates changes of cell specialization are adaptive responses to a changing environment; so pathway selection is simply the commitment to a particular change of cell specialization. The alternative developmental pathway to be considered is sexual differentiation (conjugation). After characterizing the developmental programs of cell division and conjugation in *Euplotes*, I shall address the question of determination, i.e. where in the program of cell division is the cell committed to this pathway and unable to switch to sexual differentiation. Present evidence indicates that *Euplotes* can conjugate during S-phase of the cell cycle, but probably not after predivision cortical morphogenesis begins.

METABOLISM OF DIMILIN BY *FUSARIUM* SP. S. L. Seufferer\*, H. D. Braymer\*, and J. J. Dunn\*. Dept. of Microbiology, Louisiana State University, Baton Rouge, La. 70803.

Dimilin (1-(4-chlorophenyl)-3-(2,6-difluorobenzoyl)urea), a promising new urea-based insecticide was found to be rapidly altered by four eucaryotic microorganisms. One isolate, *Fusarium* sp., was able to utilize Dimilin as a sole carbon and energy source.

The metabolites of Dimilin were identified by thin-layer and gas chromatography. Cleavage of the urea bridge by *Fusarium* sp. occurred between the carbonyl and amide groups to yield 2,6-difluorobenzoic acid, 4-chlorophenylurea, 4-chloroaniline, 4-chloroacetanilide, acetanilide, and 4-chlorophenol. Growth of the other isolates in the presence of Dimilin resulted in only two metabolites: 2,6-difluorobenzoic acid and 4-chlorophenylurea.

Analysis of the Dimilin metabolites, using the *Salmonella* mutagenicity test, revealed that high concentrations of 2,6-difluorobenzoic acid had mutagenic ability.

EFFECTS OF DIETHYLNITROSAMINE ON MURINE HEPATIC MIXED-FUNCTION-OXIDASE ACTIVITIES. A.N. Tucker\* and T. Tang, Dept. Pharmacology and Dept. Microbiology, Med. Col. of Va., Richmond, Va. 23298.

Chronic administration of diethylnitrosamine (DEN) to mice has been shown to alter liver morphology and function. The present study was undertaken to more closely examine the effects of DEN on hepatic mixed-function-oxidase activities. DEN was administered to male Balb/C mice in the drinking water at 50 ppm. Aminopyrine demethylase and aniline hydroxylase were assayed in vitro using livers from mice treated for up to 24 weeks with DEN. These two enzymes declined within 4 weeks, finally reaching values which were 30% of control at 24 weeks. The yield of microsomal protein was affected to a lesser extent, being 70% of control at 24 weeks. Cytochrome P-450 was decreased also by 24 week DEN treatment to 50% of control. These effects were similar to those produced 24 hr after a single i.p. injection of DEN at 100 mg/kg. Liver homogenates from the mice treated chronically were also used in the *Salmonella*/microsome mutagenicity test of Ames to activate several known carcinogens to mutagens. In spite of marked decreases in cytochrome P-450 associated activities, liver homogenates from DEN treated animals were able to activate the test compounds at least as well as homogenates from control animals. DEN is clearly a potent effector of murine hepatic mixed-function-oxidase activities.



RESPIRATION IN *NAEGLERIA GRUBERI*. R. R. Weik and D. T. John. Dept. Microbiol., Va. Commonwealth Univ., Richmond, VA 23298

Whole cell respiration rates and  $O_2$  tension of the culture medium were measured polarographically during agitated cultivation of the ameboflagellate *Naegleria gruberi* (EGB strain). During log growth, amebae consumed 40 nmoles  $O_2$ /min/mg cell protein which gradually depleted the dissolved  $O_2$  in the culture medium to 18% of saturation. At stationary phase, respiration rate decreased 4-fold. Intact mitochondria were isolated from *N. gruberi* and the oxidative and phosphorylative capacities of the mitochondria were studied polarographically. As with the mammalian system, the mitochondria oxidized succinate and NAD-linked substrates but unlike rat liver mitochondria, citrate and NADH were oxidized rapidly. The rates of substrate oxidation were ADP dependent and ADP:O ratios were about 2.8 for NAD-linked substrates and about 2.1 for succinate. The respiratory control ratios were 2 to 4 for 11 substrates and dependent on  $P_i$ ,  $Mg^{2+}$ , and serum albumin. KCN, azide, malonate, amytal, and rotenone inhibited electron transport the same way as that of the mammalian system. Pentachlorophenol, DNP, and bilirubin uncoupled oxidation from phosphorylation. Difference spectra of oxidized and dithionite-reduced mitochondria showed distinct absorption bands of flavins, c-type, b-type and a-type cytochromes.

PLASMID STUDIES OF ANTIBIOTIC RESISTANT *BACTEROIDES FRAGILIS*. R. A. Welch\* and F. L. Macrina, Dept. of Microbiology, MCV/VCU, Richmond, Va. 23298.

We have identified and characterized plasmid-mediated interspecies conjugal transfer of clindamycin (CC), lincomycin (LN) and erythromycin (EM) resistance from two different clinical isolates of *Bacteroides fragilis* to a *Bacteroides* sp. (High theta group). Strain V479-1 is a clinical isolate resistant to CC, LN and EM. V479-1 possesses a plasmid designated pBF4 which is ~42 Mdal in size. Strain V503 is a clinical isolate of *B. fragilis* resistant to CC, LN and EM. V503 has three plasmid species, pBF5A, pBF5B and pBF5C, which are respectively ~19, ~9 and ~4.2 Mdal in size. Conjugal plasmid transfers were performed by collecting mixtures of donor and recipient cells on nitrocellulose filters and incubating the filters anaerobically under non-selective conditions. Using V479-1 or V503 as donors and V528 (a plasmidless rifampicin resistant derivative of *Bacteroides* sp. VPI0061-1) as the recipient, drug resistant transconjugants were isolated at a frequency of  $10^{-6}$  transconjugants per input donor cell. Resistance to CC, LN and EM were always transferred en bloc. In crosses using V479-1 as donor, transconjugants now contain a plasmid equal in size to pBF4. Transconjugants in crosses using V503 as donor can be shown to acquire plasmids equal in size to pBF5A and pBF5B. Cell to cell contact is necessary for transfer and cell-free filtrates of the donor cannot mediate transfer. (Supported by NSF grant PCM 77-00858).

RESTRICTION ENZYME ANALYSIS OF THE GENOME OF MUCOID *PSEUDOMONAS AERUGINOSA*. D. O. Wood\*, F. L. Macrina, and P. V. Phibbs, Dept. of Microbiology, Med. Col. of Va., Richmond, VA. 23298.

Mucoid strains of *Pseudomonas aeruginosa*, that produce a unique alginic acid capsule, are rarely isolated from most pseudomonal infections but predominate in patients with the disease, cystic fibrosis. In these patients, mucoid *P. aeruginosa* frequently causes severe respiratory infections and death. As a means for studying the genetic basis for alginate biosynthesis, we are examining the feasibility of developing a clone bank of the mucoid *P. aeruginosa* genome. Chromosomal DNA isolated from a mucoid strain was digested with each of the restriction endonucleases EcoRI, BamHI, and HindIII and examined on agarose gels. 46% of the Hind III fragments were found to be in the molecular weight range of  $10-15 \times 10^6$  daltons while only 25% and 32% of the EcoRI and BamHI fragments, respectively, were in this range. 30-40% of the fragments from all three digests were in the  $3-10 \times 10^6$  dalton range. The fragments resulting from the Hind III digest appear to be of sufficient size and frequency to allow significant portions of the mucoid *P. aeruginosa* genome to be cloned onto a suitable vector plasmid, such as pBR322, and introduced into an *Escherichia coli*-K12 recipient. This work was supported by a grant from the National Cystic Fibrosis Foundation.

ORAL INFECTION OF MICE WITH DEFECTIVE INTERFERING (DI) PARTICLES OF HSV-1. S. S. Zenda\*, B. K. Murray, Dept. of Microbiology, Med. Col. of Va., Richmond, VA. 23219

Defective interfering (DI) particles of HSV-1 interfere with the production of standard (infectious) HSV during mixed infections in cell culture. This study was undertaken to determine whether DI particles of HSV-1 also interfere with the production of standard virus *in vivo*, thereby modulating the course of infection. BALB/c mice (six to eight weeks old) were infected by lip abrasion (oral) with either standard (low MOI passaged) or DI virus (high MOI serially passaged) of HSV-1 strain Patton. *In vitro*, the DI virus decreased the yield of standard HSV-1 by  $1.93 \log_{10}$  during mixed infections in HEp-2 cells. *In vivo*, oral inoculation with standard virus resulted in 32% mortality, whereas infection with the DI virus reduced the mortality to 7% ( $p < 0.005$ ). In addition, the mean day of death (MDD) was prolonged by 1.5 days in mice infected with the DI virus ( $p < 0.025$ ). However, the incidence, duration, and severity of the primary lip lesions was not affected by the DI virus. Oral infection with  $10^{7.7}$  PFU/ml of the DI virus produced an infection similar to infection with  $10^{6.2}$  PFU/ml standard HSV, in regard to the percent mortality and the MDD. This  $1.5 \log_{10}$  reduction in virus effectivity in producing infection suggests a  $1.5 \log_{10}$  reduction in virus yield. The results suggest that DI particles of HSV-1 modulate the course of infection *in vivo*, as well as in cell culture.

## Section of Psychology

Fifty-sixth Annual Meeting of Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

ANTERIOR AND POSTERIOR HIPPOCAMPAL LESIONING WITH MONOSODIUM-L-GLUTAMATE AND Y-MAZE REVERSAL LEARNING IN RATS. Robin G. Bernhard\* and Andrew C. Schutrumpf\* (Sponsor: L.E. Jarrard), Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

A study was carried out to examine a newly discovered technique for lesioning the brain by injecting monosodium-l-glutamate. Evidence from earlier research indicates that with this process, cell bodies are destroyed but fibers of passage remain intact. Anterodorsal and posteroventral hippocampal lesions were made by injecting 10  $\mu$ l of 1% solution directly into the structure. Fourteen male, albino rats were used as subjects. The animals were tested pre- and post-operatively in a spontaneous alternation task and open field activity. In addition, subjects were trained in Y-maze acquisition and reversal. Discussion of the results will center around the extent of the brain damage resulting from the injections and the effects on behavior. (Supported in part by NSF grant BMS 75-18160 to L.E.J.)

A BEHAVIORAL EVALUATION OF ENERGY-CONSERVATION WORKSHOPS. W.S. Brasted\*, J. Ferguson\*, K. Larson\*, E.S. Geller. Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Recently, energy-conservation workshops have been offered to various sectors of the community (i.e., residential, commercial, and governmental sectors) in attempts to both sensitize individuals to the depletion of our energy resources, and to present techniques which can save energy in the home and office. Though these workshops have been administered by two sources (i.e., the Virginia Energy Office, and an interdisciplinary team of students and professors at Virginia Tech involved in a program called the Community Education Model for Energy Conservation), both have discussed modifications of hot water use, such as turning down the thermostat of the hot-water heater, using flow limiters in shower heads, and insulating the body and pipes of the hot-water heater. Though surveys given prior to and following the workshops have indicated significant changes in attitude concerning the energy crisis and one's ability to affect significant savings in their own home, later behavioral evaluation using such dependent variables as water heater thermostat setting, presence of insulation around the body of the water heater and pipes, and the use of water flow limiters have demonstrated that this change in attitude did not, as expected, result in changes in behavior.

RAYNAUD'S SYNDROME AND THE POTENTIAL EFFICACY OF BIOFEEDBACK INTERVENTION: A REVIEW. Kathleen A. Brehony, M.S. Dept. of Psychology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va., 24061.

Raynaud's Syndrome, first described in 1862, is thought to be a disorder involving the peripheral vascular system. It occurs primarily in women and, at least in its milder form, has been estimated to afflict some 20% of the population (Lewis, 1949). Symptoms consist of intermittent vasospasms of the small vessels in the hands, feet, and sometimes in the face with a resultant blanched, mottled or cyanotic appearance of the digits and palms. The etiology of Raynaud's Syndrome is equivocal although several plausible hypotheses have emerged. Raynaud (1862) believed that sympathetic overreactivity was involved as a causal factor. Emotional stress appears to be wholly sufficient to induce vasospastic episodes in individuals suffering from this disorder. Some authors further hypothesize that suppressed anger may be involved in the phenomenon. Vehicles proposed to account for the symptoms include local vascular pathology, sympathetic discharge and biochemical phenomena. Chemical and surgical interventions have failed to produce permanent remission of symptoms and run the risk of producing undesirable side effects. Documented success with biofeedback intervention is sparse but encouraging. The study of Raynaud's Syndrome has enormous potential for the understanding of psychosomatic illness from an holistic viewpoint.

CONTROL AND REWARD MAXIMIZATION AS MEDIATORS OF RESPONSES TO COMPARISON EQUITY. B. Burch\*, D. Hudgins\*, and S. E. Arnold\*, Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Contingency over four exchanges of outputs upon inputs and output level relative to another were manipulated in a simulated work setting in which undergraduate males served as participants. Results indicated that fairness and satisfaction ratings of specific outputs received over the exchanges were influenced by comparison equity depending upon the criterion's implication for output maximization and for a controllable environment. Greater ratings of fairness and satisfaction with specific outputs were obtained when the participant either received a high overall level of output relative to another or when outputs appeared to be contingent upon inputs than when low relative outputs and an apparent lack of contingency occurred. Relative output level and contingency did not influence the effects of comparison equity upon fairness and satisfaction ratings related to overall level of output.



MIGRAINE HEADACHE AND BIOFEEDBACK: A CASE STUDY. T. A. Burling\*. Dept. of Psychology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Hand-warming biofeedback training was attempted in an adult female with recurrent migraine headaches. Results indicated a significant intra-session increase in hand temperature from baseline measures ( $p < .001$ ) and a decrease in frequency of headaches during training. However, inter-session hand temperature did not increase during training, and a significant positive correlation was noted between high hand temperature and appearance of headaches ( $p < .01$ ). The results were interpreted in reference to the findings of Sargent, Walters, and Green (1973).

EFFECTS OF TAIL-PINCH ON THE BEHAVIOR OF PRE- AND POST-WEANLING RATS. James T. Christmas\* (Sponsor: L.E. Jarrard) Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

It has been reported that amphetamine induced behavior and behavior elicited by tail pinch show many similarities in adult rats. Further, amphetamine has been found to enhance the normal tendency of pre-weanling rats to approach and maintain contact with conspecifics while the opposite effects on the behavior of post-weanling rats are found. Amphetamine also increases activity in post-weanling rats. The aim of this study was to further analyze the effects of tail pinch and relate it to the reported effects of amphetamine on behavior in pre- and postweanling rats.

The application of a mild pain stimulus (in the form of a tail pinch) was not found to significantly alter either the time spent in intraspecific contact or activity in 18-day old rat pups. In 30-day old pups tail pinch was observed to have the opposite effect of amphetamine, e.g., amount of time spent in intraspecific contact was increased and locomotor activity was significantly decreased. These results will be discussed in relation to research concerning the parallel effects of tail pinch and amphetamines on behavior in rats.

INTERVENTION FOR ENCOURAGING SAFETY-BELT WEARING. Kim Cuddihy\*, Elizabeth Jenkins\*, Robin Cutshaw\*, and E. Scott Geller. Dept. of Psychology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

In two field studies observers checked whether drivers were wearing their seat belts in cars stopped at a pedestrian intersection on a university campus. The first experiment examined relationships between seat belt wearing (i.e., an interlock system whereby the car won't start until the belt is buckled, a buzzer which sounds until belt is buckled, a buzzer which sounds for approximately 3 seconds, a light which stays illuminated until belt is buckled, or a light illuminates for about 3 seconds. While the unlimited buzzer and interlock systems were frequently discounted (i.e., more than 60%), these devices did encourage the most seat belt wearing.

A special prompting intervention to increase seat belt wearing was implemented and evaluated in the second field experiment. More specifically, drivers stopped at the pedestrian intersection were handed a flyer that used pictures, diagrams, and words to encourage seat belt wearing. Six different flyers were distributed (on different days) and a reinforcement contingency was defined on the first flyer distributed to each driver which offered a prize to anyone who could collect all six flyers. The results indicated a prominent direct relationship between the number of flyers a particular driver received and the probability that he/she was wearing a safety belt at the observation point.

RETRIEVAL PROCESSES IN THE RECALL OF REPEATED ITEMS. David G. Elmes. Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450

The free recall of words repeated at lags of 0, 2, 5, 11, and 24 events was examined in a task that minimized differential rehearsal and clustering. When subjects received instructions to learn and remember these words, recall increased across lags regardless of the type of processing instructions (neutral, search for a particular letter, or retrieve first presentation). On the other hand, when the subjects were tested for recall without forewarning, recall increased across lags only when there was an attempt to think about an item's first presentation upon presentation of its second occurrence. Moreover, the level of incidental recall was much higher when retrieval of the first occurrence was attempted than when the subjects searched for letters.

The results indicate the importance of study-phase retrieval processes in determining the level of recall and the lag effect. Study-phase retrieval was interpreted as an important learning mechanism that allows for differential rehearsal and practice in task-related retrieval.

THE EFFECTS OF OFFENDER AGE AND ATTRACTIVENESS ON SENTENCING BY MOCK JURIES. Anita Hed\* and Edward Smith, Dept. of Psychology, Longwood Col., Farmville, Va. 23901.

Pictures of physically attractive or unattractive women, who were either young or old, were attached to case reports of either a swindle or a burglary. 'Juries' of three subjects each were then asked to sentence the 'defendants' to between one and ten years in jail. It was hypothesized that the young, attractive defendant would be sentenced less harshly than the old, unattractive defendant and that this effect would be more evident in a crime of burglary than a crime of swindle, as the attractiveness of the con artist might be viewed as an integral component of the crime of swindle. The results showed that older defendants were judged more harshly than young defendants and that, for the burglary condition, attractive people were judged less harshly than unattractive people. However, in the swindle condition, attractiveness had no influence on the sentencing by the jury.

FRONTAL CORTICAL LESIONS AND SPATIAL BEHAVIOR IN THE RAT. L. E. Jarrard, and S. L. Craig, Jr\*, Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

In order to determine the effects of selective lesions of the prefrontal cortex on acquisition and retention of a complex spatial maze, 49 rats were tested on an 8-arm radial maze. Rats were divided into two control groups (operated and unoperated) and 2 groups that received bilateral lesions to either the dorsomedial prefrontal cortex or the orbital cortex. Subjects either underwent training on the spatial maze postoperatively or were trained preoperatively and tested for retention after the operations.

Performance of animals with orbital lesions was impaired in both acquisition and postoperative retention testing; dorsomedial frontal lesions were not found to affect either acquisition or performance. These results do not agree with previous research implicating the dorsomedial frontal cortex as being especially important for performance of complex spatial tasks. (Supported by NSF grant BMS 75-18160.)

A TEST OF THE CONCEPT OF ENVIRONMENTAL TRANSACTION IN PRE-SCHOOL CHILDREN USING THE AMES DISTORTED ROOM. J. S. Jamison\*, New School for Social Research; A. V. E. Harris, Department of Psychology, Radford College, Radford, VA 24142.

This study examined the effect of previous learning experience on the ability of kindergarten children to accurately respond to stimuli presented in the Ames Distorted Room. Previous experience, given in a non-distorted rectangularly shaped room conforming to the "perceived" dimensions of the Ames room, involved both viewing and touching the stimuli. The study appeared to demonstrate that pre-school children are intellectually and linguistically capable of experiencing the Ames Distorted Room phenomena. The results, however, generally did not support the contention that previous experience effected perception in this case. Explanations as to the relationship of this approach to transactional theory are discussed.

WHEN WILL PEOPLE PICK UP AND PITCH IN. E. M. Jenkins\*, K. C. Cuddihy\*, K. L. Hearn\*, and E. Scott Geller, Dept. of Psychology, V. P. I., Blacksburg, Va. 24060

Environmental interventions to control litter have included the manipulation of behavioral antecedents (to prevent littering) and behavioral consequences (to reinforce litter pick up). Prompting procedures have been effective in facilitating anti-litter behavior. However, extrinsic reinforcement has been necessary to encourage the response of picking up environmental litter.

A series of studies attempted to use prompting without positive reinforcement to facilitate the occurrence of litter-pick-up responses. The general procedure involved planting litter next to a trash receptacle and then observing the behavior of those who passed the area. The environmental settings were a college campus, a shopping mall and steps leading to motel rooms. The trash receptacle was either a 50-gallon drum or a beautified trash can. Several prompting procedures were used to facilitate the occurrence of litter-pick-up responses.

Results showed that only when both confederates continued to pick up litter did a substantial number of college students do also. Prompting without reinforcement may be sufficient to raise public awareness of the problem and prevent littering.

THE TREATMENT OF TENSION HEADACHE WITH EMG BIOFEEDBACK: A CASE STUDY. Joseph S. King, Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Many studies report successful treatment of tension headache with EMG biofeedback. Usually only moderate lowering of EMG has been reported. Michenbaum (1975, 1976) argued that cognitive factors, eg. the subject's expectations about treatment and subjective feelings associated with changes in the feedback stimulus, may enhance training and transfer of training phases of treatment.

In this study the subject's cognitive strategies were integrated within the training regimen. Results indicated that such training can be very effective over a short training period. The headaches, although occipital in origin, were best treated with frontalis feedback training. Changes in degree of muscular control were associated with changes in cognitive strategies used by the subject, as well as headache frequency and intensity and medication usage. Assessment of control over muscle tension independent of the feedback stimulus was also attempted.

CLINICAL APPLICATIONS OF LEARNED HEART RATE CONTROL: A REVIEW OF THE LITERATURE. S.B. Lovett\*, Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The literature on the clinical applications of learned heart rate (HR) control was reviewed. Case studies have demonstrated that individuals can learn to reduce the frequency of occurrence of premature ventricular contractions chronic atrial fibrillation, and the conduction patterns associated with the Wolff-Parkinson-White syndrome. Biofeedback training in HR control has been successfully employed in the treatment of episodic anxiety attacks and speech anxiety. The subjective perception of pain associated with electric shock has been reported to decrease in some subjects following successful training in HR reduction. The therapeutic potential of biofeedback training in HR control and the problems associated with HR control research using clinical samples was discussed.

BIOFEEDBACK: BEHAVIORAL MEDICINE FOR THE TREATMENT OF ASTHMA. R. L. LUSCOMB, Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24060

Overall, the findings concerning the use of biofeedback techniques in the treatment of asthma patients are encouraging. The results are generally positive and provide evidence for an effective treatment for asthmatics without the deleterious effects of drugs. Two major areas of research are examined: 1) working with EMG biofeedback reinforcement for frontalis muscle relaxation and 2) using biofeedback for a direct measure of respiratory functioning. There have been numerous studies attesting to the notion that asthma is in fact a heterogeneous disorder. Two studies involving behavior therapy and biofeedback have given some support to the predictability of success in treatment based on this heterogeneity. The focus of these studies has been on treatments aimed at reducing asthma symptoms in the individual. In considering a given person's disorder (or rather, manifested symptoms), it is imperative to consider both the biological and psychological elements at the same time. Thus, when treating the asthma patient, it is important to go beyond the treatment of the symptoms to deal with those facets of his or her life which have been affected or which affect the symptoms.

RECENT RESEARCH ON THE ELECTROMYOGRAPHIC TREATMENT OF THE TENSION HEADACHE. M.B. McNeely\*, Dept. of Psychology, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A critical review of major post-1970 experimental work aimed at substantiating claims of the clinical efficacy of EMG biofeedback in the treatment of tension headaches is presented. The link between striate muscle resting tension and subjective states of "tension" or anxiety is considered. Basic EMG biofeedback procedures are briefly described and the adequacy of the methodologies used to study the treatment is evaluated. Fruitful directions for future research are suggested and recommendations for clinical practitioners based on empirical evidence are made.



PERCEPTIONS FORMED OF THE THERAPIST AND WILLINGNESS TO DISCLOSE AS A FUNCTION OF THERAPIST DISCLOSURE. E. J. Nottingham\*, Southwestern State Hosp., Marion, Va. 24354, and R. E. Mattson\*, Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Consistent with the results of previous analogue studies on therapist self-disclosure, the current study proposed that individuals will be more willing to disclose to a therapist who exhibits high levels of self-disclosure. It was further hypothesized that congruence between what an individual expects and prefers in terms of therapist self-disclosure and the actual amount of disclosure presented by the therapist will have a positive impact on the perceptions formed of the therapist. In a between-subjects factorial design, 80 male and 80 female undergraduates listened to a segment of a simulated psychotherapy session in which the level of therapist disclosure, i.e., high or low, was either congruent or incongruent with their previously stated expectancies or preferences for level of therapist disclosure. Hypotheses were confirmed in that subjects showed a greater willingness to disclose to the therapist who used a high level of disclosure and subjects rated the therapist more positively in the congruent conditions than in the incongruent conditions. The implications of these data for the psychotherapeutic process are discussed.

ATTITUDES TOWARD THE MULTIHANDICAPPED: CHANGES ACCOMPANYING A TRAINING PROGRAM AND SUBSEQUENT EXPERIENCE IN A RECREATIONAL CAMP SETTING. S. H. Patterson\*, R. E. Mattson\* and E. S. Geller. Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Undergraduate students majoring in psychology, education, and recreation were first trained in therapeutic recreational, educational, and psychological counseling techniques and then implemented a six-day residential camping experience for multihandicapped individuals from a state institution. Attitudes of the undergraduates towards the multihandicapped were assessed during training and before and after participation in the camping experience. At the beginning of the project the overall perceptions of the multihandicapped individual were more positive than at successive attitude assessment periods. However, in contrast, at the beginning of the project the multihandicapped individual was perceived as more insane, sad, and unsuccessful than at successive assessment periods. While changes in attitudes occurred in the training phase of the project, there were minimal attitudinal changes as a function of the actual camping experience. Specific attitude changes are discussed in terms of project activities.

EVALUATION OF TITLE IX IMPLEMENTATION AS A FUNCTION OF SEX AND ORIENTATION TOWARD WINNING. T. D. Phillips\*, and J. A. Sgro, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Male (N=140) and female (N=140) collegiate athletes were separately divided into two groups based on their orientation toward winning (OTW). They were examined on the variables of birth order, community, years of competitive participation, playing to be with friends, and playing for enjoyment only. The major item of interest was whether the groups differed with regard to the importance ranking of Title IX provisions for a women's athletic program relative to low oriented female athletes. High oriented female athletes were older in birth order, came from largely rural areas than urban, and participated in team than individual sports. The major Title IX difference was a higher ranking of the athletic scholarships provision by the high than low oriented female athletes. The latter finding was also found in the male groups. With males, high-oriented athletes had more years of participation and played less for the purpose of being with friends. The OTW index was significantly different between males and females and also between the low and high groups for each sex. The results were discussed in relation to the current implementation of Title IX.

BIOFEEDBACK TREATMENT OF ESSENTIAL HYPERTENSION: A REVIEW OF OUTCOME STUDIES. A. C. Patsiokas\*. Dept. of Psychology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24060

Essential hypertension is a serious medical problem that is estimated to affect 15%-30% of the population of the U. S. The dangers of prolonged hypertension are increased risk of cardiovascular disease and strokes, which are two of the major causes of death in the U.S. Both the nervous system and environmental factors are etiologically important in essential hypertension.

The therapeutic value of operant conditioning-feedback techniques with essential hypertensives has been investigated in a number of studies. These studies will be reviewed with attention to the type of clinical response focused on (systolic blood pressure, diastolic blood pressure, or both), the treatment outcome, and the adequacy of the experimental design. The evidence from these studies supports the therapeutic utility of biofeedback in the treatment of essential hypertension.

MIGRAINE HEADACHE: A REVIEW OF OUTCOME RESEARCH. S. H. Patterson\*. Department of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Several well-controlled studies allowing comparison of the procedures currently employed in the management of migraine headache pain were reviewed. These studies have largely involved digit temperature biofeedback with autogenic phrases compared with some other form of treatment. The relevant variables are sufficiently similar to draw some conclusions regarding the treatment of migraine. Digit temperature biofeedback was not shown to be more effective than relaxation in four separate studies, lending strong support for the conclusion that relaxation training is the most effective therapeutic component to date. A tentative explanation of this finding is discussed, as are some supportive psychophysiological findings.

ALERTNESS VERSUS ENCODING: TESTING A TWO-FACTOR MODEL. Carol Pilgrim\*, Alan Kraut, E. Scott Geller. Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24060

The present series of studies was done in order to test a two-factor model of attention by investigating the conflicting findings of two different types of "familiarity" effects. One group of researchers have reported that a familiar stimulus results in faster reaction times than a novel stimulus while other researchers have found the reversed phenomenon, where a familiar stimulus elicits slower reaction times. A choice reaction time (RT) paradigm which allowed for within subject variations of familiarization was used in order to differentiate alertness and encoding, the two attention components. The findings of each of our experiments were supportive of the two-factor model which suggests that the alertness elicited by a stimulus is held to decrease as a result of repeated presentation of the stimulus while encoding is facilitated simultaneously. We found that a few presentations of a stimulus resulted in faster RT's to a familiar stimulus due to facilitated encoding, while repeated presentations of a stimulus elicited slower RT's to the familiar stimulus because the alertness decrement was sufficient to mask the facilitated encoding. When RT's are slower to a familiar stimulus than to a novel one, the alertness decrease outweighs the encoding increase and conversely, when RT's are faster to a familiar stimulus, the encoding facilitation has the advantage.

## BIOFEEDBACK AS AN INTERVENTION FOR DYSMENORRHEA. L.E.

Scott\* and K.A. Brehony. Dept. Of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

It is becoming increasingly apparent that dysmenorrhea - painful menstruation or cramps - is the result of a complex interaction between physical and psychological components. Dysmenorrhea is a well-defined clinical entity which occurs in about 50% of women at some time in their lives. The pain is reported in the pelvic area and is caused by spasmodic contractions of the uterus. In a single case design, electromyographic readings of abdominal muscle tension was found to be significantly above baseline levels during the first day of menstruation. This data further suggests that biofeedback may be an effective means of training abdominal muscle relaxation to reduce painful cramping during menstruation.

## EFFECTS OF SCOPOLAMINE ON SPATIAL MEMORY IN THE RAT.

John D. Stout\* (Sponsor: L.E. Jarrard) Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

An experiment was conducted to evaluate the effects of the anti-cholinergic scopolamine on short-term memory (STM) using a spatial discrimination task. A Latin Square design was used for the two dosages of scopolamine hydrobromide (1.0 mg/kg, 0.5 mg/kg). The animals were trained on an 8-arm maze on which only four of the eight choices were reinforced. This enables one to look at both working memory (STM) (where working memory is measured by the number of correct choices repeated in one trial) and reference memory (LTM) (determined by the number of non-reinforced choices visited in a trial). The rats were tested under the two drug doses and performance was compared with that obtained on several nondrug preliminary training days. It was found that under the larger dose performance was impaired to the extent that the animals would not run. However, with the smaller dose the animals ran the maze but working memory was significantly impaired ( $p < .05$ ). These data support the theory that cholinergic mechanisms play an important role in the expression of STM. (Supported in part by NSF grant BMS 75-18160.)

## EFFECTS OF MINIMAL VISUAL CUES ON SPATIAL MAZE PERFORMANCE BY RATS. William T. Thistlethwaite\* and Jay A. Lutins\*.

Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450

The present series of studies was concerned with the role of visual cues in determining performance on an eight-armed radial maze. One experiment showed that after learning the maze, albino rats could perform adequately in the dark. A second study showed that performance after the rats had been enucleated was accurate but slow. A third study indicated that the maze could be learned by a blinded animal. Under conditions of minimal visual cues, errors early in a trial were much more detrimental to accurate performance than were errors that occurred late in a trial.

The results indicate that visual cues are not necessary for retention or learning of the maze. Although visual information may aid performance, it is quite likely that the working memory of a rat is, in part, based on nonvisual information.

## BRAINWAVE CHARACTERISTICS AND CLINICAL APPLICATION OF EEG BIOFEEDBACK. G.A. Weiss\*. Dept. of Psychology, Va. Polytechnic Inst. &amp; State Univ. Blacksburg, Va. 24061.

EEG characteristics and terminology were briefly discussed, followed by a critical review of the literature on the application of EEG feedback to clinical populations.

Research on EEG feedback with clinical populations is still in its infancy. Reports consisted largely of pilot, and case studies and typically lacked a control group. From the available data it appeared that EEG conditioning was less easily accomplished in clinical populations relative to the normal subjects of earlier research, and that generalization tended to be poor in the clinical groups.

The basic rationale for brainwave conditioning treatment was questioned, and the lack of normative EEG data in clinical subgroups noted. It was suggested that further research in this area be directed toward an examination of the assumptions underlying EEG feedback as a psychotherapeutic technique, and efforts to isolate and identify the specific therapeutic components of EEG feedback.

## VISUAL SEARCH VERSUS MEMORY SEARCH IN A REACTION TIME PARADIGM. G.A. Weiss\*, C. Pilgrim† S. Hicks† and E. Scott Geller

Dept. of Psychology, Va. Polytechnic Inst. & State Univ. Blacksburg, Va. 24061.

Memory search and visual search rates were compared within subjects. The stimuli were letters projected onto a screen in front of the subjects (N=20). The sequence of events for each of 280 trials was as follows: A "memory" list of letters appeared, which the subject turned off by pulling simultaneously a left- and a right-hand RT trigger. After 3 sec. a warning buzzer sounded, followed by the onset of a "recognition" list. The subject pulled the left- or right-hand trigger as quickly as possible to indicate whether the memory and recognition lists included the same letter. A single target letter appeared as the memory list on the 140 visual search trials, and as the recognition list for the 140 memory search trials. The search set (presented either as a memory list or recognition list) contained 3, 5, or 7 letters.

RTs were analyzed according to the factorial of 2(Search Task: Visual/Memory) X 2 (Response Type: Match/No-Match) X 3(Search Set Size: 3/5/7). Search rate was significantly faster for memory search than visual search as evidenced by the flatter slopes for memory search. There was a significant Response Type X Search Set Size interaction for visual search only, indicating that visual search was a self-terminating process whereas memory search was exhaustive.

## THE RELATIONSHIP BETWEEN PERSONALITY VARIABLES OF A MIGRAINE SUFFERER AND PERFORMANCE IN BIOFEEDBACK TRAINING OF FINGER TEMPERATURE: A CASE STUDY. L. J. Solomon† Dept. of Psychology, Va. Polytechnic Inst. &amp; State Univ., Blacksburg, Va. 24061.

This single case study investigated the relationship between the personality variables of a migraine sufferer and her performance in biofeedback training to increase her finger temperature. Personality characteristics were determined by interview and by completion of the Bem Sex-Role Inventory and the MMPI. It was found that the data were largely consistent with the description of the "migraine personality" already characterized in the literature. Additionally it was noted that these personality variables (e.g., perfectionism, need for achievement, low frustration tolerance, and a tendency toward neuroticism) may interfere with success in biofeedback training. Finally, the relationship between the actual migraine experience and objective and subjective evidence of helplessness and lack of control were discussed.



## Section of Space Science and Technology

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
May 9-12, 1978, Blacksburg, Virginia

CONDENSATION IN THE LANGLEY 0.3-m TRANSONIC CRYOGENIC TUNNEL - ITS CAUSES AND EFFECTS. R. M. Hall, NASA, Hampton, Va., 23665.

Cryogenic wind tunnels should be operated at the lowest possible total temperature in order to maximize the advantages of cryogenic operation, such as increased Reynolds number and reduced drive power requirements. However, the minimum operating temperature is limited by the onset of condensation effects. A research effort at the NASA Langley Research Center has been underway to determine under what conditions condensation occurs and to determine the effects it may have on aerodynamic testing. Results are presented from an experimental program utilizing total pressure probes mounted at various downstream stations in the Langley 0.3-m transonic cryogenic tunnel. Comparisons are made with theory assuming heterogeneous nucleation on pre-existing seed particles. A possible source of the seed particles is identified and discussed. Extending the findings to larger tunnels is also examined.

EARTH RESOURCES AND ENVIRONMENTAL SENSING WITH A LARGE APERTURE MICROWAVE RADIOMETER. L. S. Keafer, Jr., Space Systems Division, NASA-Langley Research Center, Hampton, VA 23665

An Earth resources and environmental sensing mission is defined for a spaceborne microwave radiometer. Mission study results list specific requirements for six measurements and define the associated orbital parameters and radiometer performance specifications. The radiometer concept selected for a design study is a large aperture (>200m) nonphased array system for all weather, high resolution sensing of soil moisture and coastal zone parameters. A large spherical reflector used with a linear array of identical radiometers at the focal plane in a push-broom mode provides a wide-swath high resolution "image." Preliminary system study results indicate advances are required in large space system technologies and in multibeam radiometry.

ADVANCED TREFFTZ PLANE DRAG OPTIMIZATION FOR NON-PLANAR, SUBSONIC CONFIGURATIONS. John M. Kuhlman, Dept. of Mechanical Engineering and Mechanics, Old Dominion Univ., Norfolk, Va. 23508

A theoretical method has been developed for the determination of span load distribution for minimum induced drag for non-planar subsonic configurations. Trailing vortex density strength is assumed to vary piecewise linearly with spanwise coordinate. Optimization is achieved either through use of Munk's criterion or a direct optimization technique, whereby analytical expressions are developed for derivatives of the drag with respect to the unknown wake strengths. Solutions using both techniques agree well with available exact solutions. (Aided by NASA Grant NSG - 1357)

SOME HIGHLIGHTS OF AERODYNAMIC RESEARCH AT THE LANGLEY RESEARCH CENTER - PAST, PRESENT AND FUTURE. E. C. Polhamus\*, Head, Fluid Dynamics Branch, NASA Langley Research Center, Hampton, Va 23665

Some selected highlights of aerodynamic research performed at the Langley Research Center from the mid-1940's will be reviewed and the impact of the research on the development of advanced military and commercial aircraft will be described.

First, some of the research leading to concepts such as the swept wing, the area rule, variable wing geometry and vortex lift which characterize many of the modern aircraft are presented. Next, some of the more recent research which has resulted in concepts which are currently emerging as strong candidates for application to new generations of aircraft is reviewed. Finally, the paper will indicate some possible new directions in aerodynamic research at the Langley Research Center and describe some current developments in research facilities which are expected to enhance the center's research capabilities in the future.

A CALIBRATION TECHNIQUE FOR HOT-WIRE VECTOR ANEMOMETERS. J. Scheiman\*, Aeronautical Res. Scientist, NASA Langley Res. Ctr., Hampton, Va 23665

Calibration tests of hot-wire flow measuring probes were conducted to evaluate their capability of measuring velocity magnitude and direction. A newly developed test-rig and data acquisition system were developed for obtaining a large amount of data in a relatively short period of time. A comparison of two probes of identical model and manufacture indicated significant differences in response and flow interference. Using a three-wire probe, pre- and post-calibrations and flow angle limits of  $30^\circ$  (velocity direction with respect to the probe axis), the mass flow rate was measured with a 3 percent accuracy and flow angle errors of  $20^\circ$  were observed. However, with extensive calibrations, these flow angle errors can be reduced to  $5^\circ$ .

CRUISE MISSILES - A HISTORICAL PERSPECTIVE.

M. Leroy Spearman\*, Aerospace Engineer, High-Speed Aerodynamics Division, NASA Langley Research Center, Hampton, VA 23665

The U.S. is currently placing emphasis on the development of cruise missile systems such as the Navy Tomahawk and Harpoon, and the Air Force air-launched cruise missile (ALCM) and ground-launched cruise missile (GLCM). Some of the major milestones in the history of cruise missiles are presented. During World War I, for example, the British developed a radio-controlled Flying Target and the U.S. developed the Kettering Aerial Torpedo. Further significant advances were not made until World War II when the Germans developed the V-1 Buzz Bomb. Subsequent exploitation of German technology by the U.S. and the U.S.S.R. produced some important results. The development of several post-World War II U.S. cruise missiles that are no longer in the inventory is discussed, and the current operational U.S.S.R. cruise missile inventory is described. Some of the significance of cruise missile philosophy is also pointed out.

EXPERIMENTAL INVESTIGATION OF LIQUID FUEL INJECTION FROM THE TOP OF A STRUT. S. I. Baranovsky\* and J. A. Schetz\* Dept. of Aerospace and Ocean Engr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va 24061

Flow patterns around a strut injector with liquid injection were investigated by optical techniques. Data obtained for  $M = 3$  air flow with jet/freestream dynamic pressure ratios from 2.5 to 15.0; angles of injection from  $30^\circ$  to  $150^\circ$  and different jet nozzle diameters, show that injection from the top of the strut can be used for increasing the penetration with minimum additional dynamic pressure losses and distortion of flow in a combustion chamber. Previously obtained correlations for penetration and shock's shape obtained for the wall and flat plate injection can be used for this particular flow field. Separation of liquid film upstream of jet nozzle and formation of oblique shocks from spray's outer boundary behind the injection shock are discussed.

GEOMETRICAL AND PHYSICAL OPTICS ASPECTS IN HOLOGRAPHIC FLOW VISUALIZATION. A. W. Burner\*, W. K. Goad\*, and J. E. Jordan\*, NASA, Langley Research Center, Hampton, VA 23665

Typical flow visualization data using various holographic techniques are presented for three Langley facilities: The Pilot Model Expansion Tube, the Hypersonic (Mach 6)  $CF_4$  Tunnel, and the Hot Gas Radiation Research Facility. A first order geometrical optics model of holography combined with the classical calculation of interference fringes generated by two point sources is used to describe the various holographic flow visualization techniques. With this model the nature of reference fringes generated during reconstruction of holographic interferograms at wavelengths and geometries other than that used for initial hologram exposure can be predicted. The adjustments necessary to produce various fringe spacings and orientations for the dual plate method as well as an alternate method of interferogram reconstruction are presented. The effects of apertures near the schlieren focus on model image sharpness and the effects of tempered tunnel windows on flow visualization data are discussed.

SEMICONDUCTOR MATERIALS GROWTH IN LOW-G ENVIRONMENT. I. O. Clark\*, R. K. Crouch\*, A. L. Fripp\*, and W. J. Debnam\*. Flight Electronics Division, NASA Langley Research Center, Hampton, VA 23665

Experimental and theoretical research into the growth of semiconductor materials in a low-g environment is presently underway in the Flight Electronics Division on NASA - Langley Research Center. This research consists of a two-pronged experimental approach dealing with: (1) the growth of  $Pb_{1-x}Sn_xTe$  by various techniques in a 1-g environment to obtain the best possible material, and (2) the growth of  $Pb_{1-x}Sn_xTe$  in a space environment aboard the Spacelab using three different techniques. Concurrent theoretical research is treating problems associated with constitutional supercooling in the growth of semiconductor materials. The relative orders of magnitude of the parameters involved in the heat and/or mass transfer equations are to be investigated.

This talk will describe some of the various growth techniques to be investigated on Earth. In addition, the three growth techniques currently planned for the low-g environment will be discussed. Finally, an overview of the theoretical studies planned and under consideration will be presented.

AERODYNAMIC CHARACTERISTICS OF FORWARD SWEEP WINGS. J. F. CAMPBELL, J. F. Huffman\*, and R. P. Boyden\*. Fluid Dynamics Branch, Subsonic-Transonic Aerodynamics Division, NASA Langley Research Center, Hampton, VA. 23665

Recent advances in composite materials and aeroelastic tailoring show promise of alleviating the weight penalty associated with the divergence of forward swept wings. Similar to aft sweep, forward sweep delays the effects of transonic compressibility, but the divergence problem has limited its application. If forward swept wings prove to be structurally practical and aerodynamically efficient, then the aircraft engineer will be able to evaluate the relative advantages of forward and aft swept wings in new designs.

The current paper traces the history of forward swept wing research and presents results of an investigation to examine the aerodynamic characteristics of a general research fighter configuration having forward and aft swept wings. Experimental longitudinal, lateral-directional, and roll damping data are presented and compared with appropriate attached flow and vortex flow subsonic theories.



SOLUTION OF THREE-DIMENSIONAL PARABOLIZED NAVIER-STOKES EQUATIONS USING PSEUDO ELIMINATION. P.R. Gogineni and Clark H. Lewis. Department of Aerospace and Ocean Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

The solution of three-dimensional parabolized Navier-Stokes equations for hypersonic flow over bodies at high angle of attack has been a time consuming process which takes a modern computer (e.g. IBM 370/158) several hours. Recently, a new technique called the pseudo-elimination method was proposed by Helliwell for the solution of a system of second-order partial differential equations. The technique involves approximating the inverse of the solution matrices within an iterative procedure. The solution matrices are then easily solved by the tridiagonal algorithm. When the iterative procedure converges, the exact inverse is obtained. We have applied this technique to the solution of three-dimensional parabolized Navier-Stokes equations for the hypersonic flow over spherically blunted cones at high angles of attack. The results have been compared with those obtained using another solver developed earlier by Lubard and Helliwell. The pseudo-elimination method increased the speed of computations by a factor of 1.4 and resulted in unique and better behaved solutions.

CONSTRUCTION OF THE INTRINSIC COORDINATE SYSTEM AND PRESSURE DISTRIBUTIONS OF LOW-ASPECT WINGS FOR THREE-DIMENSIONAL BOUNDARY-LAYER EQUATIONS. Osama A. Kandil and Jeffrey J. Kelly\*, Engr. Science & Mechanics Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

To solve the first order boundary-layer equations by a finite difference scheme and guarantee its stability, one must satisfy the Courant-Friedrichs-Lewy condition and Raetz-Influence Principle. These conditions may be easily satisfied by integrating the boundary-layer equations in terms of an intrinsic-coordinate system (the external streamlines on equipotential-lines). Furthermore, the boundary conditions and the initial conditions must be provided before integrating the boundary-lines equations.

In this paper, we developed a method for constructing the intrinsic-coordinate system on the suction and pressure sides of low-aspect-ratio wings with sharp-edge separations. The method also provides the pressure distributions and the lines of external flow attachment. The exact equation and boundary conditions of the external flow problem are solved by a nonlinear discrete-vortex method. Next, the equations of the external streamlines and equipotential lines are integrated and the lines of attachment are determined. The method is applied to two rectangular wings (aspects ratios 1 and 3) over a wide range of incidence ( $10^\circ$ - $20^\circ$ ). The accuracy and convergence of the numerical results ensured that the method is reliable. (Aided by Army Office of Research, N.C. Grant No. DAAG 29-76-G-0034 and by NASA Grant No. NSG 1262)

THE SIGNIFICANCE OF SHOCK AND BODY SLIP CONDITIONS ON JOVIAN ENTRY HEATING. S. N. Tiwari and K. Y. Szema\*. Dept. of Mechanical Engineering and Mechanics, Old Dominion Univ., Norfolk, Va. 23508

The hypersonic entry conditions encountered by a probe entering the Jupiter's atmosphere are such that the heating environment is extremely severe. The initial onset of heating is convective followed by a much shorter yet more intense radiative heating pulse. At the onset of the convective heating pulse, the flow regime is such that the Reynolds numbers are small. For this type of flow condition the slip boundary conditions, both shock and wall, become important. In this study, therefore, the influence of both the body and shock slip conditions on the Jovian entry heating is investigated for a typical entry trajectory. Realistic thermo-physical and radiation models are employed and results are obtained by implicit finite difference and iterative procedures. The results indicate that the effect of the slip conditions is significant when the altitudes are higher than 225 KM and that the contribution of radiative heat flux should not be neglected at any altitude.

This work was supported by NASA-Langley Research Center through Grant NAS1-14193-27.

NONLINEAR DYNAMIC-AERODYNAMIC INTERACTION. D. F. Thrasher\*, D. T. Mook and A. H. Nayfeh\*. Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

The nonlinear unsteady vortex-lattice technique in conjunction with a predictor-corrector method is used to calculate the dynamic response of a thin three dimensional wing moving through an incompressible fluid. The problem is posed in terms of a moving reference frame attached to the wing. With the present technique, there are no restrictions on the planform, angle of attack or aspect ratio as long as separation occurs along sharp edges only. Examples include directed motion problems in which time histories of aerodynamic coefficients and wake position are calculated for various prescribed maneuvers. And the aerodynamic procedure is coupled with the equations of motion to predict the response of a hinged wing. The loads exhibit hysteretic behavior during cyclic motion and hence aerodynamic damping is observed.

ATMOSPHERIC TURBULENCE BELOW 75 M IN THE CONVECTIVE BOUNDARY LAYER (STRONG WIND CONDITIONS). H. W. Tieleman, S. E. Mullins\*, Dept. of Eng. Sci. and Mech., Col. of Eng., VA Polytechnic Inst. and State Univ., Blacksburg, VA 24061

Mean as well as turbulent velocity and temperature measurements obtained from the 76m micrometeorological tower at Wallops Island, Virginia are discussed. The measurements were obtained with cup-vane instruments and aspirated temperature probes (5 levels) for mean profiles as well as with hot-film probes (6 levels) for turbulence parameters. The wind conditions during data acquisition can be classified as moderately strong (at least 10 m/sec at the 15m level) with winds coming from directions varying between north and west. These conditions are usually encountered following the passage of a cold front. Observations have been compared with strong wind results as listed in several review papers. A new scheme is developed for the normalization of the velocity spectra using a reduced frequency related to the characteristic length scale of the velocity components associated with the inertial subrange.

## Section of Statistics

Fifty-sixth Annual Meeting of the Virginia Academy of Science  
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THE EEOC AND THE 80% RULE. J. V. Bowen, Jr. Dept. of Mathematics, University of Richmond, University of Richmond, Va. 23173

The 80% Rule is used by several federal agencies as a sufficient criterion for a prima facie case of job discrimination. The 80% Rule is shown to be unequally stringent for different employers and a rule is proposed which is shown to be equally stringent.

EXTENSION OF RANKED-SET SAMPLING THEORY TO SAMPLING WITH A COVARIATE. M.J. Conroy\*. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Ranked-set sampling is a procedure based on order statistics which is applicable when quantification of sampling units is difficult or time consuming, but units may be easily drawn and ranked in small sets. Ranked-set sampling is similar to stratified random sampling, but has the advantage of being applicable when no prior stratification of the population is possible, since stratification is accomplished during the course of the sampling procedure. The theory of ranked-set sampling is reinvestigated with the purpose of extending that theory to sampling with a covariate. According to the proposed sampling procedure, paired observations on the variable of interest (Y) and a correlated variable (X) are made employing ranked-set sampling, where ranking is based on Y. Regression estimators for the mean of Y are examined and shown to be unbiased. Under the assumption of joint normality of Y and X, ranked-set regression estimators are shown to give theoretically more precise estimates than either ranked-set or regression estimators alone. Simulated sampling experiments from a bivariate normal distribution comparing estimates based on simple random sampling, double sampling for regression, ranked-set sampling, and combined ranked-set and double sampling, suggest that these theoretical results may be reasonable for small sample problems.

QUEUEING NETWORKS WITH FEEDBACK. R. L. Disney\*. Dept. of Industrial Engineering & Operations Research, Va. Polytechnic Inst. & State Univ., Blacksburg, VA. 24061.

In this paper, some of the basic concepts of queueing theory will be reviewed. The major thrust of the paper will be to discuss what is called a queue with instantaneous feedback. Such queues have been used to model many systems including computer networks.

A general framework for queues with instantaneous feedback will be given and some properties derivable from this structure will be discussed. Attention will then be devoted to a very simple problem that seems to be misunderstood. It will be shown that such a simple problem has some unusual properties that one does not expect based on "obvious" results. A few unsolved problems in this area will be exposed for future research.

THE STATE OF QUEUEING NETWORKS AS SEEN BY POISSON ARRIVALS. R. D. Foley. Dept. of Industrial Engineering and Operations Res., Va. Polytechnic Inst., Blacksburg, Va. 24061

In an M/G/1 queue the invariant distribution for the queue length imbedded at arrivals is the same as the invariant distribution for the queue length at an arbitrary point in time. This result is extended to queueing networks which can be represented as a Markov process on a countable state space. It is shown that the invariant joint distribution for the state of the network imbedded at Poisson arrival points is identical to the joint invariant distribution at an arbitrary point in time.



A BAYESIAN APPROACH TO CONTINGENCY TABLES. I.J. Good, Dept. of Statistics, VPI&SU, Blacksburg, Va. 24061

A Bayesian test for the hypothesis  $H$  of independence of the rows and columns of a contingency table, requires the calculation of the Bayes factor against  $H$ . This equals  $P(E|not H)/P(E|H)$  where  $E$  denotes the innards  $(n_{ij})$  of the tabel. A Bayesian model is proposed that is a natural extension of one that had given interesting results for multinomials, based on mixtures of Dirichlet distributions. A statistic  $G$ , based on the Type II likelihood ratio, has an asymptotic distribution that is sometimes a good approximation when the tail-area probability is smaller than  $10^{-40}$ ! The model also provides an evaluation of the (small) amount of evidence contained in the marginal totals. The work is a good example of the Bayes/non-Bayes compromise or synthesis and was supported in part by HEW, NIH Grant #R01GM18770.

References: (i) *The Estimation of Probabilities*, MIT 1965; (ii) "A Bayesian significance test...", *JRSS* 29 (1967) 399-431 (with discussion); (iii) "The Bayes factor...Dirichlet prior", *Ann. Statist.* 3 (1975), 246-250; (iv) "...Dirichlet distributions...", *Ann. Statist.* 4 (1976), 1159-1189; (v) IJG & J.F. Crook "The Bayes/non-Bayes compromise...", *JASA* 69 (1974), 711-720; (vi) IJG & J.F. Crook, "The enumeration of arrays...", *Discrete Math.* 19 (1977), 23-45; (vii) J.F. Crook & IJG, Part II of iii unpublished; (viii) B. Levin and J. Reeds, "...a conjecture of I.J. Good," *Ann. Statist.* 5 (1977), 79-87.

REANALYZING ROSENBERG'S SELF-ESTEEM DATA BY USING INTERNAL GOODNESS-OF-FIT INFORMATION. S. K. Lee\*, Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

In a survey reported in Rosenberg (1962, *Social Forces*), a sample of high school students in New York City were cross-classified according to their self-esteem, religious affiliation and father's education level. A goodness-of-fit test indicated that the interaction among the three qualitative variables is significant. In the present paper, we analyze the data set by using information in the estimated parameters of loglinear models, which leads to partitioning the data into two subtables. Further analysis is given to the subtables and the result is then interpreted.

ON THE ESTIMATION OF OVERALL MEAN IN MULTI-STAGE SUCCESSIVE SAMPLING. Dharam S. Rana. Old Dominion University, Dept. of Math & Comp. Sci., Norfolk, VA

In sampling on successive occasions, partial matching of sampling units in a three-stage design is considered. Two sampling patterns are used to obtain the estimators of the population mean over  $h$  ( $h > 2$ ) occasions. A comparison between two estimators is made through their relative efficiencies for some selected values of the population values and the design quantities. The optimum distribution of sample subject to a suitable cost function is investigated for a special case.

THE USE OF PRINCIPAL COMPONENTS IN MULTIVARIATE QUALITY CONTROL. Y. V. Hui. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Process control charts based on Hotelling's  $T^2$  statistic have been used for processes having more than one quality characteristic. A location parameter inspection plan also based on  $T^2$  is presented with the additional feature that principal components are used diagnostically for assigning causes when the process is out of control. Test statistics are updated through confidence bounds on the coefficients of the components. Operating characteristics of  $T^2$  charts are studied in terms of average run lengths for the case that the process is in control and for cases when it is not.

A SIMPLE SEQUENTIAL CRITERION FOR TESTING A NORMAL MEAN WITH UNKNOWN VARIANCE. J. E. Mann\*. Dept. of Statistics, VA Polytechnic Inst., Blacksburg, VA 24061

A simple sequential test of the null hypothesis  $H_0: \mu = \mu_0$  versus the alternative  $H_1: \mu > \mu_0 + \delta$  ( $\delta$  a positive constant) is proposed for a normal population with mean  $\mu$  and unknown variance. The test criterion, denoted by  $L_n$ , is based upon Wald's theory of weight functions. Wald's Stopping boundaries  $B < A$  are employed. Although the proposed test does not have the double minimax optimality of Wald's sequential  $t$ -test, it is far simpler to apply. The proposed test is shown to have the following properties. (1) It terminates finitely with probability one. (2) If  $\epsilon > 0$  and the sample path  $(y_1, \dots, y_n)$  leads to rejection of  $H_0$ , then  $(y_1 + \epsilon, \dots, y_n + \epsilon)$  will never lead to acceptance of  $H_0$ , but under certain restrictions on  $\bar{y}$  and  $\epsilon$  will lead to rejection. (3)  $P[L_n > A]$  is an increasing function of  $\mu$  over an interval which includes  $\mu + \delta/2$  and  $\mu + \delta$ . and  $P[L_n < B]$  is a decreasing function of  $\mu$  over an interval which includes  $\mu + \delta/2$ . (4) The test is shown to be insensitive to outliers. The effect of an outlier is the postponement of a decision to a later stage. (5) Finally, a simulation is used to discover other important properties of the test.

THE EFFECT OF MODEL INADEQUACY ON HUBER'S M-ESTIMATES OF REGRESSION COEFFICIENTS. D. A. Binkley\* and R. H. Myers. Dept. of Statistics, Va. Polytechnic Inst. and State Univ. Blacksburg, Va. 24061.

The effect of unfitted second-order coefficients on the asymptotic properties of fitted first-order coefficients is considered for robust regression using Huber's  $\psi$  function. In particular, asymptotic bias and variance are examined for specific designs and error distributions.

THE PRICE OF GASOLINE: FORECASTING COMPARISONS. A.E. Bopp Dept. of Economics, James Madison University. J.A. Neri, U.S. Dept. of Energy.

Gasoline prices are simulated using three popular forecasting methodologies: a Box-Jenkins type, an econometric type, and a simple regression type. One period ahead and eighteen period ahead comparisons are made. For the one period ahead method, a Box-Jenkins type time series model simulates best, although all do well. However, for the eighteen period ahead simulation the econometric and the regression methods perform better than the Box-Jenkins formulation. A rationale for and implications of these results are presented.

A FRAMEWORK FOR ALLOCATING INVENTORY RESOURCES FOR MULTIPLE-USE PLANNING. H. E. Burkhardt, and R. D. Stuck. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

In the past, the basic approach to gathering data for multiple-use planning has been to collect large amounts of information from all possible sources. This process has several shortcomings. First, the information gathered may not be appropriate for the planning decisions under consideration. Second, the cost of data collection may be greater than necessary because not all of the information is used.

Inventories with well defined objectives are required because inventory costs are rising and more complex decisions must be made. A user-oriented approach for gathering multiple-use planning inventory data is presented. The sequence is to determine (1) the decisions to be made with the aid of inventory data, (2) the data needed to soundly base the decisions, and (3) the impact of sampling error in the data on the decisions. Sample intensities that minimize the cost of obtaining data plus the expected losses from using the data to make decisions are determined.

A cost plus loss minimization framework for multiple-use planning inventory was developed and applied to a case study on a U. S. Forest Service planning unit. Results indicated that the procedure should provide useful guides for allocating sampling resources.

THE CAUSAL ANALYSIS OF MULTIPLE TIME SERIES (preliminary report). Michael L. Deaton and Robert V. Foutz, Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

This paper discusses the concepts of causality and of the internal consistency of a causal scheme (path diagram) for a set of univariate weakly stationary time series. Path analysis, first introduced by Wright (Ann. Math. Stat., 5 (1934), 161-215) is extended to time series data by the use of the theory of spectral analysis. The notions of path coefficients and path diagrams for multiple time series are defined. The theory for checking the internal consistency and feasibility of a causal scheme is also developed, using linear filter theory and the theory of the coefficient of coherence developed by Koopmans (Ann. Math. Stat., 35 (1964), 532-549, 1765-1780). General rules for path tracing techniques and the decomposition of coherence are also developed for time series data.

A RANDOM PARAMETER APPROACH TO MODELING AND FORECASTING TIME SERIES (preliminary report). Deborah A. Guyton and Robert V. Foutz. Dept. of Statistics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The dependence structure of a stationary time series can be described by its autocorrelation function  $\rho_k$ . Consider the simple autoregressive model of order 1:  $Z_t = \phi Z_{t-1} + a_t$  where  $\phi \in (-1, 1)$  is fixed and the  $a_t$ 's are iid  $N(0, \sigma_a^2)$ .

Here  $\rho_k = \phi^{|k|}$ ,  $k=0, \pm 1, \pm 2, \dots$ . It can be argued that as  $\phi$  ranges from 1 to -1, the behavior of the corresponding AR(1) model changes from that of a slowly changing, smooth time series to that of a rapidly changing time series. This motivates a generalized AR(1) model where the coefficient itself changes stochastically with time:  $Z_t = \phi_t Z_{t-1} + a_t$  where  $\phi_t = \delta_1 \phi_{t-1} + \delta_0 + b_t$  with  $\delta_1$  and  $\delta_0$  fixed,  $b_t$ 's iid  $N(0, \sigma_b^2)$  and independent of  $a_t$ . This paper obtains conditions on the parameters for stationarity of the model. Also, techniques are provided for model identification, for conditional maximum likelihood estimation, and for minimum mean squared error forecasting. Similar developments are made for higher order models.

COMBINING INFORMATION FROM INCOMPLETE BLOCK DESIGNS. Thomas E. Norwood\*, Ortho Pharmaceuticals, and Klaus Hinkelmann, Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061.

In this paper the following situation is considered: Several replicates of an incomplete block design (such as a BIB design) are to be analyzed together, assuming a mixed model with treatment effects fixed and block effects random. It is assumed that the replicate effect is additive and the error variance remains constant, but the block effect variance changes from replicate to replicate. The problem to be discussed is how to estimate treatment contrasts utilizing the inter-block information from all replicates.

For the BIB case three estimators are considered. Conditions are derived under which these estimators have uniformly smaller variance than the intra-block estimator, and (in two instances) a combined estimator which utilizes the inter-block information from only one replicate. Upper bounds for the variances of these estimators are given along with guidelines for their use. These estimators may be applied to a series of BIB designs which do not have the same treatments but do have some treatments in common.

ECONOMICALLY OPTIMUM DESIGN FOR CUSUM CHARTS. M. Hsu\* and M. Reynolds. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

The design of Cusum Charts to control the mean of the process based on a minimum cost criterion when there are several assignable causes occurring randomly with known shifts is studied. A loss-cost model is developed which is a function of both the design parameters of the Cusum Chart and the cost and risk factors associated with the process. Brown's method is used in obtaining the optimum solutions of sample size, sampling interval, decision limit, and reference value. A Brownian motion approximation for the ARL is employed in the model.

The effects of changes in the design parameters and in some of the cost factors are studied numerically. It is also found that the multiple assignable cause model can be approximated by a certain single assignable cause model.



JOINT DISTRIBUTIONS OF NORMS OF SPHERICALLY INVARIANT VECTORS. Y. M. Lam\* and D. R. Jensen. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Rayleigh distributions are the distributions of the norms of Gaussian vectors having important applications to a variety of practical problems; for example, signal detection, ballistics, and statistical inference. If the class of Gaussian vectors is extended to the elliptical family or, more specifically, to the subfamily which contains mixtures of Gaussian vectors, then a distribution of norms of a mixture of Gaussian vectors is also a mixture of Rayleigh distributions. This study is concerned with joint distributions of this type. In large samples, it is shown that such mixtures of Rayleigh distributions can be approximated by a mixture of Gaussian distributions. Certain inequalities are given for joint probabilities in terms of probabilities having simpler structure.

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# THE SPRING 1978 COUNCIL MEETING ACTIONS

*VAS Acting Secretary:* Dr. S. Gaylen Bradley departed from the U.S. on study leave. Mrs. Vera Remsburg will serve as acting secretary until a new secretary is elected in May 1978.

*Future Annual Meetings:* A site committee for the 1981 conference is to be appointed to visit Randolph-Macon College in Ashland.

*AAAS Activities:* Dr. E. L. Wisman was voted president-elect of the American Association for the Advancement of Science for 1978-79.

- Fifteen VAS members contributed their services as session chairpersons at the 1978 AAAS meeting in Washington, DC.
- Dues from state academies to the AAAS have been raised from 5 cents to 10 cents per academy member.
- AAAS research grant requests for high school projects, requested by the state, must be received by March 1st. Surplus available funds, if any, will be redistributed based upon proposals received before June 1.
- Awards are based upon merit, and the disbursed amount is proportional to the state academy membership. Virginia proposals presently receive \$445.00 from this source.

*Editor, VJS:* Dr. K. P. Chopra outlined some developments pertinent to the Journal. These included increased diversity in subject areas, closer adherence to a viable, established schedule and financial shortfalls resulting from regularized publication of the Journal. An area of major concern is the ponderous load on the editor, who has received feedback and support from only a small number of academy members and editorial officers. Increasing the term of service of section editors from the customary one year should lead to increased contributions and support from that hitherto-untapped segment of the Academy.

Council approved an "in principle" authorization for expenditure of up to \$15,000.00 over the next 3 years to cover any shortfalls in the Journal's operational budget. This will not obviate a projected deficit this year. Increased operational expenses for the Journal were discussed, and the need for additional revenues was stressed repeatedly. Such revenue may emanate from abstract/reprint charges, increased subscription rates, increased advertising or endowment sources. The committees on Fund-Raising, Publications, and Constitution and Bylaws are to investigate the ramifications of the aforementioned funding sources in their particular areas.

*VAS Awards:* Honorary Life Membership in the VAS is bestowed upon Beverly Orndorff, Science Writer for the Richmond Times Dispatch. Mr. Orndorff was cited for his contributions to the furtherance of science in the Commonwealth.

*VAS Finances:* The Journal's accelerated publication rate, necessitated to bring it back on schedule, has caused increased expenditures which will lead to a deficit this year. While the Academy finances are in good condition, the need for future increased revenues is becoming more evident.

Fund raising for the trust fund has progressed satisfactorily. A total of \$877.00 in gifts has been received from the academy membership.

*VJAS Activities:* Glen C. Poole of Annandale and Susan Hinton of Portsmouth represented the Virginia Junior Academy of Science at the American Junior Academy Meeting held this year. The students' abstracts were included in the official AAAS listing.

Twenty-five research awards totaling \$445.00 were distributed and used for high school research projects during the past year.

*VAS Membership Status:* The academy presently ranks in the top five, nationally, in terms of membership. A complete membership roster is planned for inclusion in the Spring 1979 edition of the Journal.

*Academy Officers, 1978-79:* The Nominating Committee submitted the following slate of officers for consideration at the 1978 annual meeting (additional nominations can be made from the floor at the conference):

President-Elect:	Herbert McKennis, Jr. Vera B. Remsburg
Secretary:	Kenneth P. Bovard Harold Marshall
Treasurer:	Warwick R. West, Jr. Donald G. Cochran

*Ad Hoc Committee to Plan a Science Advisory System:* The committee has received an invitation to serve as an advisory body to the State Science, Engineering and Technology Study. This study, scheduled for completion in August 1978, is under a grant from the National Science Foundation. The effort is in cooperation with the Commonwealth of Virginia's Department of Intergovernmental Affairs, directed by Mr. Charles A. Christopherson. The committee's principal changes are to:

- Analyze efforts, in Virginia and in other states, aimed at mainstreaming science, engineering and technology into the decision-making processes of the Governor, his staff and his cabinet.
- Inventory the science, engineering and technological resources available to the Governor, his staff and his cabinet. This would encompass State agencies, State and private institutions, private enterprises, Federal agencies, interstate organizations and other resources.

The joint group is to be involved in submittal of a final written report to the agency outlining the analyses and findings of the information mentioned above.

Compiled by  
Michael N. Bishara  
Associate Editor for Science and Society  
from notes supplied by  
Vera B. Remsburg  
Acting Secretary



# NEWS, NOTES AND ANNOUNCEMENTS

## SECTIONS ELECT EDITORS

The following are the Section Editors who were elected by their respective sections during their business meetings held on May 10, 1978:

<i>Section</i>	<i>Editor</i>	<i>Affiliation/Address</i>
Agricultural Sciences	R. J. Stipes	417 A Price Hall VPI & SU Blacksburg, VA 24061
Astronomy, Mathematics and Physics	Samuel P. Bowen	Department of Physics VPI & SU Blacksburg, VA 24061
Biology	Patrick F. Scanlon	Dept. of Fisheries and Wildlife VPI & SU Blacksburg, VA 24061
Botany	David A. Breil	Department of Natural Sciences Longwood College Farmville, VA 23901
Chemistry	Robert G. Bass	Department of Chemistry Virginia Commonwealth Univ. Richmond, VA 23284
Education	C. Dillard Haley, Jr.	Department of Education Radford College 900 Fairfax Street Radford, VA 24141
Engineering	Walter R. Hibbard	301 Holden Hall VPI & SU Blacksburg, VA 24061
Environmental Sciences	Michael Garstang	Dept. of Environmental Sciences University of Virginia Charlottesville, VA 23337
Geology	Roddy V. Amenta	Department of Geology James Madison University Harrisonburg, VA 22801
Materials Science	L. J. Corsa, III	Babcock and Wilcox Naval Nuclear Fuel Division P.O. Box 785 Lynchburg, VA 24505
Medical Sciences	Charles O'Neal	Department of Biophysics MCV-VCU Richmond, VA 23298
Microbiology	Paul V. Phibbs, Jr.	Dept. of Microbiology MCV-VCU Richmond, VA 23298
Psychology	Frank S. Murray	Randolph-Macon Women's College Lynchburg, VA 24503
Space Science and Technology	James F. Campbell	NASA Langley Research Center M. S. 287 Hampton, VA 23665
Statistics	J. Van Bowen, Jr.	Department of Mathematics University of Richmond Richmond, VA 23172

## INVENTORY OF PROGRAMS IN SCIENCE, MATHEMATICS AND ENGINEERING FOR WOMEN AND GIRLS

The National Science Foundation has asked the American Association for the Advancement of Science to survey programs in science for women and girls. The results will appear in a publication that describes all efforts made between 1966 and the present to improve the science, mathematics, and engineering education of girls and women in the United States and to increase their participation in science-related careers.

Programs directed at any age level, as well as work conducted by any type of organization or agency, are eligible for inclusion. Projects of direct benefit to women and girls and research on the topic will be surveyed.

Persons who know of projects which might be within the scope of this inventory are asked to *write* Dr. Michele L. Aldrich, OOS-AAAS, 1776 Massachusetts Avenue, N.W., Washington, D.C. 20036, or *phone* (202) 467-5431.

## THIRD PHILIP MORRIS SCIENCE SYMPOSIUM

Structures and biochemistry of natural biological systems will be the theme of the third Philip Morris Science Symposium scheduled for November 9, 1978. The symposium consists of six invited lectures dealing with various aspects of natural-product science including natural polymers, physical aspects of plant cell walls, enzyme systems, and reaction mechanisms.

The invited speakers are Paul J. Flory, 1974 Nobel Laureate, department Chairperson and Jackson-Wood Professor of Chemistry at Stanford U.; Peter Albersheim, Professor of Molecular Biology, U. of Colorado; Robert H. Marchessault, department Director and Professor of Chemistry, U. of Montreal; Britton Chance, Johnson Professor of Biophysics, U. of Pennsylvania; Daniel E. Koshland, Jr. Professor of Biochemistry, UC at Berkeley; and R. Malcom Brown, Professor of Botany at UNC.

Inquiries for additional information may be addressed to Karol G. Sharp, Philip Morris Research Center, P.O. Box 26583, Richmond, Virginia 23261.

## HUGHES TREES AT MAYMONT

A collection of trees was planted at Maymont as a living memorial to Dr. Roscoe D. Hughes—educator, scientist, and environmentalist. The trees were dedicated on April 15 in a ceremony which included remarks by Dr. E. Clifford Nelson, retired professor of parasitology at MCV-VCU and a close friend of Dr. Hughes, and unveiling of a dedicatory plaque by Dr. Hughes' grandchildren.

Maymont's extensive grounds offered the perfect setting for trees favored by Dr. Hughes. Thus far, a black gum, scarlet oak, green ash, live oak, bald cypress, red oak, silver maple, and shagbark hickory have been planted. Each bears a tag identifying it as a Hughes memorial tree, and indicates the tree's Latin and common names. The trees were made possible by contributions to the Museum Foundation.

Dr. Hughes was a major force in the establishment of the Science Museum of Virginia, and he served as the first Chairman of its Board of Trustees. He was Professor Emeritus of Biology and Genetics at MCV, having retired in 1970 as department's chairman.

A dedicated member of the Virginia Academy of Science, Dr. Hughes was its past President (1965–66). He received the 1970 Ives F. Lewis Distinguished Service Award. In 1974, he cofounded the Environmental Sciences section which later instituted two student paper awards in his honor and memory.

## SMITHSONIAN INSTITUTION FELLOWSHIPS

The Smithsonian Institution awards a few predoctoral and postdoctoral fellowships each year in support of higher education and research training in residence at the Smithsonian in the fields of anthropology, biological sciences, earth sciences, and the history of technology and science. Predoctoral fellowships are offered to investigators who have completed preliminary course work and examinations, and are engaged in dissertation research. Recent recipients of the doctorate who seek further research training are eligible for postdoctoral fellowships. Five predoctoral and fifteen postdoctoral fellowships were awarded for 1978–79.

Proposals for research in residence at the Smithsonian using collections, facilities and laboratories and pertaining to research interests of the Smithsonian research staff may be offered in research areas including the following: *Anthropology*: archeology, ethno-history, ethnology, linguistics, physical anthropology, and C-14 dating. *Biological Sciences*: systematics of fossil and recent vertebrates, invertebrates and plants, radiation biology, carbon dating, animal behavior, plant and animal physiology, animal pathology, tropical biology, ecology, and field biology. *Earth Sciences*: sedimentology, paleobiology, mineralogy, petrology, meteoritics, and volcanology. *History of Technology and Science*: history of mathematics, physical sciences, medicine, pharmacy, engineering, transportation, agriculture, air and space, electrical technology, and history of science in America.

The predoctoral and postdoctoral fellowships carry respective stipends of \$7,000. and \$12,000. plus research allowance. For more information and application forms, write to: Office of Fellowships and Grants, Smithsonian Institution, Washington, D.C. 20560. The deadline for applications is *January 15, 1979*.

## AOAC ANNUAL OCTOBER MEETINGS

The Association of Official Analytical Chemists (AOAC) will hold its 92nd annual meeting October 16–19, 1978 at the Marriott Hotel, Twin Bridges, Washington, D.C. Current developments in analytical methodology pertaining to agriculture, environmental and public health areas will be presented and discussed. About 200 papers will be given on new techniques, methods, and instrumentation for analysis of foods, drugs, pesticides, cosmetics, feeds, fertilizers, mycotoxins, beverages, colors, forensic science, materials, hazardous substances, vitamins, water and air pollutants, microbiological and extraneous materials, contamination of foods, and related subjects.

A symposium on toxicological tests is planned. Evening agenda include two workshops on: reverse phase chromatography, October 17 (EM Laboratories, Inc.) and automated analysis, October 18 (Technicon Instrument Corp.).

## SIXTEENTH ANNUAL VIRGINIA STATE SCIENCE TEACHERS CONFERENCE

Earth Science (Meteorology) is the theme of the Sixteenth annual Virginia State Science Teachers Conference cosponsored by the Virginia Academy of Science, Department of Education, and Virginia Association of Science Teachers to be held on October 27–28, 1978 at Hotel Roanoke, Roanoke, Virginia.

Drs. Joanne M. and Robert H. Simpson of the University of Virginia's Department of Environmental Sciences will be the principal lecturers. They will present an introductory lecture on applications of weather modification to meteorological systems on the evening of October 27. The morning lecture on October 28 will deal with climate, long and short term weather modification, and severe weather phenomena. The lecture will be illustrated through films and slides. Mrs. Ida Beaton and Mr. P. K. Black will cover laboratory and classroom activities which relate broad principles of climate and weather to students' day to day encounters with changing weather.

The workshop shall meet partial requirement for one graduate credit. Teachers desiring credit shall be required to submit typed report on a one-month (part-time) study project to Dr. R. Wesley Batten, the course director. Registration fee for credit is \$36.50. The University coordinator is Dr. Ertle Thompson, School of Education, University of Virginia, Charlottesville, Virginia 22903.

## ASAS HONORS TECH PROFESSORS AND GRADUATING SENIOR

At its 70th annual meeting held at Michigan State University on July 9–13, the American Society of Animal Science (ASAS) elected *Dr. Thomas J. Marlowe* as Honorary Fellow and *Dr. Milton B. Wise* as President-Elect. Professor Marlowe is a past President of the ASAS, and Dr. Wise heads the Animal Science Department at VPI & SU.

The National Block and Bridle Club selected *Mr. Mike McDowell*, a graduating senior at VPI, as the top student of animal science in the U.S.A. The first Va. Tech. student to win this honor, Mr. McDowell received his award at the ASAS banquet on July 12.



## CHILDREN'S REHABILITATION CENTER CONFERENCES

Fifteen major continuing education conferences touching on a variety of handicapping conditions and therapeutic treatment techniques as well as other issues of concern to professionals who work with disabled children have been announced for the 1978-79 academic year by the Children's Rehabilitation Center, part of the University of Virginia Medical Center in Charlottesville, Virginia.

The wide spectrum of topics covered in this year's conference schedule are designed to include many of the subjects which the Center feels need to be addressed as well as a number of others which have been suggested by previous conference participants. Four handicapping conditions will be discussed in detail: muscular dystrophy, spinal cord injury, cerebral palsy, and scoliosis. Other major areas include pediatric orthopedic nursing and nursing care of the handicapped child and his family, facilitating the adoption of handicapped children, and a genetics update. In addition, three weekend sport symposiums will be offered on therapeutic horsemanship, therapeutic swimming and adaptive aquatics, and shooting sports. Two day conferences include *feeding techniques for the handicapped child*, *treatment of high risk infants*, and *ethical issues in decision making in the care of the handicapped child*.

Conference faculty will be comprised of nationally known experts, physicians from the University of Virginia Medical School as well as professional members of the Center's multidisciplinary

team. The format calls for both didactic sessions and small informal discussion seminars, as well as "hands-on" training workshops. Persons desiring further information on any of these conferences should contact Anne Raynor, Conference Coordinator, Children's Rehabilitation Center, Route 250 West, Charlottesville, Virginia 22901 or call 804-924-5161.

## SUMMER FELLOWSHIPS AT MOUNTAIN LAKE BIOLOGICAL STATION

Several fellowships are available to graduate students for summer study in 1979 at U. Va.'s Mountain Lake Biological Station. In addition to Drs. C. DeRosa and M. Kelley of U. Va., the visiting faculty participating in summer instruction shall include Drs. C. R. Bell (UNC), A. E. Brooks (Wabash College), L. R. Brown and Judith E. Skog (George Mason U.), H. H. Burdsall, Jr. (USDA, Madison, Wis.), G. W. Byers (U. of Kansas), D. W. Johnston (U. of Florida) G. L. Miller (Eisenhower Coll.), Susan Moyle (Cent. Coll. Kentucky) and L. J. Musselman (ODU). For further information and application forms write to: Director, Mountain Lake Biological Station, University of Virginia, Charlottesville, Virginia 22903.

**Vivian Welker**  
Editorial Assistant

# PAPERS TO APPEAR IN FALL 1978 ISSUE

## GUEST EDITORIAL

Society's View Toward Science and Technology. *Donald P. Hearth*, NASA Langley Research Center.

## ARTICLES

Pigments in the Fungal Genus *Endothia*. *Martha K. Roane and R. Jay Stipes*, VPI and SU.

Retrieval in Human Memorization. *David G. Elmes*, Washington and Lee University.

Potential of Summer Rain Augmentation by Cloud Seeding in Mid-Atlantic States. *Joanne Simpson*, University of Virginia, and *Barbara Gail Brown*, South Dakota School of Mines.

Potential of Detecting Urban and Oceanic Thermal Anomalies from Space. *Kuldip P. Chopra and Lewis W. Webb, Jr.*, Old Dominion University, and *Gilmore H. Trafford*, NASA Wallops Flight Center.

An Annotated List of Odonata of Southeastern Virginia. *James F. Matta*, Old Dominion University.

A Dense Ultraviolet Source. *Ja H. Lee*, Vanderbilt University, and *Donald R. McFarland*, NASA Langley Research Center.

## NOTES

Xanthic Creek Chub, *Semotilus atromaculatus*, from West Virginia. *Robert F. Denoncourt*, York College of Pennsylvania and *Charles H. Hocutt and Jay R. Stauffer, Jr.*, University of Maryland.

Sublethal Thermal Shock Effects on Predation Susceptibility of Fathead Minnows. *Ronald M. Clayton*, VPI and SU, and *O. Eugene Maughan*, Oklahoma State University.

## SCIENCE AND SOCIETY ESSAY

Accountability for Research in Agriculture. *James R. Nichols*, VPI and SU.

## FEATURES, REPORTS AND ANNOUNCEMENTS

Protection of Virginia Flora. *Richard S. Grover*, Maymont Foundation

Virginia Fisheries: Managing a Living Resource. *Kuldip P. Chopra*, Councilman, Environmental Sciences Section.

Symposium Honors James Jacob. *Vivian Welker*, Editorial Assistant.

Psychology in Virginia. *William M. Hinton*, Washington and Lee University, and *Frank S. Murray and Frederick B. Rowe*, Randolph-Macon Women's College.

Kizer Replaces Jackson as Business Manager.

## MEMBERSHIP

The Academy membership is organized into sections representing various scientific disciplines.

Addressograph plates of all members are coded by a section number. The **First Number** indicates the member's major interest and enables Section Officers to more easily contact their members.

1. Agricultural Sciences
2. Astronomy, Mathematics & Physics
3. Microbiology (Bacteriology)
4. Biology
5. Chemistry
6. Materials Science
7. Engineering
8. Geology
9. Medical Sciences
10. Psychology
11. Education
12. Statistics
13. Space Science and Technology
14. Botany
15. Environmental Sciences

### Annual Membership Dues

Approved March 18, 1973

Business .....	\$100
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Regular .....	10
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\* \$25 or more

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# GENERAL NOTICE TO CONTRIBUTORS

The Virginia Journal of Science welcomes for consideration original articles in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

Articles (other than abstracts, correspondence and comments, and news and notes) should be sent to the Editor, Dr. Kuldip P. Chopra, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA. 23508. Manuscripts dealing with science and society, history of science and technology, correspondence, and news and notes should be addressed to the Associate Editor, Dr. Michael N. Bishara, Engineering Division, Southwest Community College, Richlands, VA. 24641. Short notes (not exceeding eight double-spaced typed pages, 2500 words or equivalent including illustrations) may be sent to the Editor or one of the members of the Editorial Board. Proofs, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

The original and **three** copies of each manuscript and small photo copies of large drawings are required. All articles should be typewritten, double-spaced throughout, on one side of good bond paper ( $8\frac{1}{2} \times 11$  inches). Margins should be not less than  $1\frac{1}{4}$  inches on any border. Each manuscript should be complete and final when submitted, and should include the following:

1. Title, author's name and affiliation, and dateline appearing on a separate page.
2. Author's glossy photograph and brief (50 word) professional biography including name, position, degrees received (when and where), awards and honors, and principal research interests.
3. Abstract. An abstract summarizing the text, particularly the results and conclusions, is required at the beginning of each article. This should appear on a separate page.
4. Text. The text should be divided into sections and subsections (if necessary), each with a separate heading. Section headings should be typed on a separate line and centered. Subsections should be set into the text and underlined. Sections and subsections should **not** be in capitals.
5. Acknowledgements.
6. References. Literature cited in the text should follow the name- and year-format: Birkhoff and Zarantonello (1957), or (Simpson and Dennis, 1974). List of references, in the section so titled, should be arranged alphabetically on a separate page. Abbreviations for journal articles should conform to the List of Periodicals in the Chemical Abstracts Service Source Index, the American Institute of Physics Style Manual or the Bibliographic Guide for Editors and Writers.

Each reference should be complete and in the following form: author(s), year within parentheses, title of article, title of journal (abbreviated and underlined or

typed in script), volume number (underline with wavy line), and pages. For a book: author(s), year, title of book (underlined or typed in script), page, publisher and city of publication. Examples:

Birkhoff, G. and Zarantonello, E. H. (1957): Jets, Wakes and Cavities, pp. 280-293. Academic Press, New York.

Chopra, K. P. (1961): Interactions of Rapidly Moving Objects in Terrestrial Atmosphere. *Rev. Mod. Phys.* **33**, 153-172.

Simpson, J. and Dennis, A. S. (1974): Cumulus clouds and their Modification. In *Weather Modification* (W. N. Hess, ed.), Chap. 6, pp. 229-280, Wiley, New York.

**References to project or company reports, technical memoranda and personal communications are not permissible**, except as footnotes under exceptional situations. Footnotes in the text should be numbered serially throughout a manuscript.

7. Illustrations. Glossy prints are preferred to oversized original drawings. The lettering on the latter should be such that the smallest character after reduction is about 1.5 mm high. Each figure should be mentioned specifically in the text. Figure number and legend will be set in type and **must not** be part of the drawing. All legends should be typed together, and figures identified by author's name and figure number in pencil on the back.
8. Tables. Each table should be numbered in Roman numerals, carry a title which is complete and intelligible, should have clear and concise column headings and should be typed on a separate page. Indicate units where needed. Footnotes should be designed by a superior lower case letter (a, b, c, etc.) and should begin anew for each table.
9. Mathematical Symbols and Formulas. Formulas should be composed carefully for utmost clarity and economy. Equations should be identified with numbers within parenthesis at the right-hand margin. The word equation(s) in the text should be abbreviated Eq(s). Radical sign should be avoided; to indicate roots, use a fractional exponent. For fractions, use solidus (/), the negative exponent or the division sign. Examples:  $a/b^{1/2}$ , or  $ab^{-1/2}$ , or  $a \div b^{1/2}$ . Avoid double-line fractions, double subscriptions or superscripts, and indicate vectors or matrices by placing a wavy line under the symbol. When the exponent  $e$  is modified by a complicated exponent, use the symbol  $\exp$ . Use of International System of Units is preferred. Explain unusual symbols with marginal notes in pencil.

Please note that the above format is a change from the past practice in the Journal. Manuscripts not conforming to the above guidelines shall be returned. There are no page charges at the present time. However, the VJS reserves the right to make page charges for very long manuscripts, and to bill the authors at cost for unusually complicated illustrative material, extraordinary alterations in the text in proof, or when major retyping of the manuscript is warranted.





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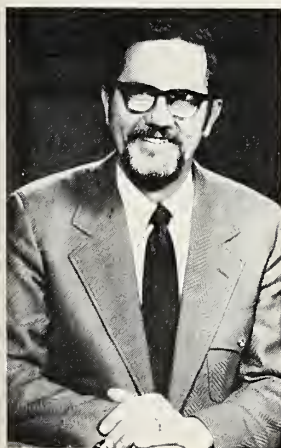
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## SOCIETY'S VIEW TOWARD SCIENCE & TECHNOLOGY

Donald P. Hearth

*Director, Langley Research Center*



Donald P. Hearth, Director of NASA's Langley Research Center in Hampton, Virginia, is a graduate of Northeastern University and the Federal Executive Institute, and has done graduate work at UCLA and USC. Prior to becoming Langley's fourth director since its founding in 1917, Hearth spent 24 years as an aeronautical researcher, project manager, space program planner and director, and administrator of laboratory research and space flight projects. He has received several awards and other forms of recognition from NASA and the American Institute of Aeronautics and Astronautics. He received an honorary Doctor of Science degree from George Washington University in 1978.

It is no longer possible or practical for scientists and engineers to ignore society's perception of the value of their work. The public is becoming more aware of technology's exponentially increasing impact on our lives and continuously forms value judgments concerning the work of scientists and technologists. Unfortunately, these judgments are not always based upon facts and logic; i.e., society does not use the *scientific method* in judging the value of science and technology. Perhaps society's judgments are based upon *What's in it for me?* Consequently, society's perception of technology's value tends to oscillate from one extreme to another, and sensitive scientists may become paranoid as they attempt to understand where they stand with the public.

The past 25 years illustrate society's changing perception of technology. In the late 1950's and early

1960's, technology was viewed as the provider of the *good life*, whereas a view commonly held in the late 1960's and early 1970's was that technology was bad in that it was destroying our environment, fueling an unjust war in Viet Nam, etc. Clearly, this drastic shift resulted from other factors such as unfulfilled promises and expectations and the extremely rapid pace of life brought about by the speed of travel and communication. In recent years, however, it seems that the public is shifting toward a less negative view of technology.

It is important for scientists and engineers to understand this changing attitude and to recognize that we have contributed to it. For too long we have failed to accept responsibility for the application of our technology. Today's society is the product of major technological advances made in the past century. With the many good results have come some bad ones; for example, technology has accelerated man's ability to pollute his environment. I agree with the view expressed by chemist George Kistiakowsky when he stated—"Scientists can no more be blamed for the misuses to which their discoveries or devices are put than artists and writers can be blamed for the misuses to which their arts are put on Madison Avenue." Nevertheless, we must recognize that misapplications will occur which will influence society's value judgments of technology, and we must do what we can to minimize such misapplications and to honestly communicate with the public relative to them.

We have also been guilty of overpromises. Technology has not, as yet, found a cure for cancer, cleaned up the cities, increased our productivity to overcome inflationary forces in our economy, or developed economic nonfossil fuel energy sources as many of us have promised. Technology is neither the villain that it has been made out to be nor is it the savior for all of society's ills. Those of you who are committed to the advancement of science and technology must realize that technological solutions alone are not sufficient for many of society's problems.

I am convinced, however, that technology can and will assume an extremely important and positive role in the future of man. Those of us at NASA's Langley Research center are extremely proud of Langley's contributions to the development of aviation during our laboratory's 61-year history. Today aeronautical



products are very important to the nation's economy; for example, they contributed about \$7 billion to the positive side of the U.S.'s international balance of payments in 1977. Perhaps more important is the potential of advances in air travel and electronic communication in bringing the world's people together as we better understand one another's cultures, needs, and values.

The future will not be a technological paradise, but technology does have the promise to improve the quality of life for all of the world's citizens. However, technology must have a chance to "do its thing." This requires that society have a balanced view of tech-

nology and that all elements of society learn to cope with and to properly apply technology. This also requires that scientists and engineers recognize the power of their technology and accept the responsibility that goes with such power.

We scientists and engineers should be proud of our work. We must, however, climb down from our ivory towers and accept the responsibilities that we have to society. We must not overpromise what technology can do and when. We must work to minimize technology's misapplications and help the public to understand what technology is all about.

# Pigments in the Fungal Genus *Endothia*

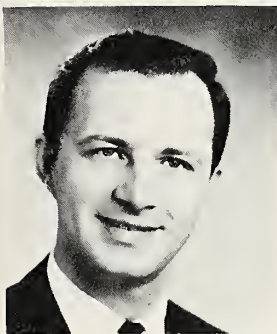
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**Abstract**—Pigmentation in the genus *Endothia* is reviewed. Presence or absence of skyrin, oxyskyrin and rugulosin is reported for the first time for *E. coccolobii*, *E. eugeniae*, *E. havanensis*, *E. japonica*, *E. macrospora*, *E. singularis* and *E. viridistroma*. Pigments found in the present study in *E. gyrosa*, *E. longirostris*, *E. parasitica*, *E. radicalis* and *E. tropicalis* are compared with those previously reported for these taxa.

## Introduction

The usage of differences in primary and secondary metabolites in conjunction with variation in morphologic characters in speciation is documented for higher plants in Alston and Turner (1963), Binns and Blunden (1969), Crawford (1972), Levin and Schaal (1970) and others. However, biochemical systematics has not been widely applied to fungi. Tyrrell (1969) in his review article on biochemical systematics and fungi suggested that, among other areas, the study of pigments that are secondary metabolites might contribute to fungal taxonomy. The members of the genus *Endothia* comprise a group in which the pigment patterns may be readily established by chromatography.

The fungal genus *Endothia*, whose history is summarized by Roane and Stipes (1976), contains three

taxa causing tree diseases and several others which apparently are not severely pathogenic. *Endothia parasitica*, introduced into the United States from the Orient, caused the most dramatic and disastrous tree disease in the United States. Less than 50 years after its discovery, the blight was present throughout the natural range of the American chestnut. Recently, *E. gyrosa* has caused a devastating blight of pin oak in many areas of Virginia. Acute die-back of clove trees caused by *E. eugeniae* was reported in 1952 by Nutman and Roberts. In addition, several species of *Eucalyptus* have been cankered by *E. havanensis* in Surinam (Boerboom and Maas, 1970).

So far as is known, all members of the genus produce colored mycelium and stromata. Pigmentation ranging from yellow to chestnut brown has been associated with the various taxa of the genus *Endothia* since the description by Schweinitz (1822) of the orange stromata of *Sphaeria gyrosa* Schw. Later Fries (1849) established the dull yellow-red-colored genus *Endothia* and included in it the fungus earlier called *Sphaeria gyrosa*. The characterization of species of *Endothia* by a yellow or orange stroma is noted by Hawkins and Stevens (1917). The exception to this characterization is *E. viridistroma* Weh. (Wehmeyer, 1936) with dark green stromata.

It was Pantanelli (1911) who made the first comment on the chemical character of the pigmentation of these fungi: "Anche il micelio superficiale é giallo vivo per uno lipochromo in gocce che contengono le sue cellule; il micelio interno é gialliccio." (Even the superficial mycelium is bright yellow on account of a lipochrome in drops which the cells contain; the internal mycelium is yellowish.) (translation from the C. L. Shear file on chestnut blight.)

Later, P. J. Anderson (1913) noted for *E. parasitica* (Murr.) P. J. and H. W. And that on potato agar the mycelium began to turn yellow in four to six days due to the production of a pigment in the cells, and he ascribed the characteristic color of the spore tendrils and stromata on the bark of chestnut to this pigment. He suggested that the pigment was an aurin rather than a lipochrome. Shear et al. (1917) reported that when grown on white corn meal medium, *E. gyrosa* (Schw.) Fr., *E. fluens* (Sow.) Shear and Stevens and *E. singularis* (H. Syd.) Shear and Stevens changed the color of the medium to perilla purple, although *E. longirostris* Earle, *E. parasitica* and *E. tropicalis* Shear and Stevens did not.

Working with *E. fluens*, *E. parasitica* and *E. tropicalis*, Hawkins and Stevens (1917) described three pigments, A, B, and C. They found that pigment A



was common to the three taxa tested. All three pigments were found in *E. fluens*, and the yellow pigments A and C were found in *E. tropicalis*. It was noted that pigment B, the only one of the three pigments soluble in water, was the cause of the "perilla purple" color in cultures of *E. fluens* and frequently formed red crystals on the mycelium. Hawkins and Stevens decided that, although pigments A, B, and C had some properties in common with aurin, the conclusion that they were the same as aurin was unsubstantiated, and there was not enough evidence to assume that they were lipochromes. Sando (1919) studied pigment B as described by Hawkins and Stevens. He named it endothine red, assigned it the empirical formula  $C_7H_5O_4$ , and concluded that it was probably related to members of the pyrocatechin group.

It was not until 1953 that Shibata et al. working with *E. parasitica* and *E. fluens* described an orange pigment, endothianin, and a yellow pigment, radicalisin. Later, Shibata et al. (1955a, b) identified endothianin as skyrin described by Howard and Raistrick (1954) and radicalisin as rugulosin described by Breen et al. (1955). The considerable work carried out under the direction of Dr. Shibata has resulted in the clarification of the chemistry of the pigments found thus far in members of the genus *Endothia*. Four pigments, skyrin, skyrinol, oxyskyrin, and rugulosin, illustrated in Figure 1, have been reported to occur in members of this genus (Shibata et al., 1955a, b, 1957; Briggs and LeQuesne, 1965). Skyrin (I), ox-

yskyrin (II) and skyrinol (III) are 1,1'-bisanthraquinones formed by oxidative coupling, while rugulosin (IV) is a modified bisanthraquinone (Shibata, 1967, 1973).

Gatenbeck (1960) indicated that the mechanism of the formation of anthraquinones (viz, skyrin) should fundamentally be the same as that of other acetate products such as orsellinic acid. Shibata and Ikekawa (1963) found that rugulosin also was synthesized by the malonate-acetate condensation. A biogenetic scheme for the production of these pigments from acetyl and malonyl CoA was presented by Shibata (1967).

The use of pigments as taxonomic characters in the genus *Hypoxylon* by Greenhalgh and Whalley (1970) presented the possibility that the bisanthraquinone pigments found in the various taxa of *Endothia* might be useful taxonomic characters for separation of these taxa. Since the pigment content of five of the species of *Endothia* has been previously reported, we proposed to verify those pigments reported for *E. fluens*, *E. gyrosa*, *E. longirostris*, *E. parasitica* and *E. tropicalis* and to determine the pigments present in the remaining taxa.

#### Materials and Methods

The present work on pigments in *Endothia* spp. has been carried out with cultures or stromal tissue of 12 species of *Endothia*: *E. coccolobii* Vizioli, *E. eugeniae* (Nutman and Roberts) Reid and Booth, *E. radicalis*

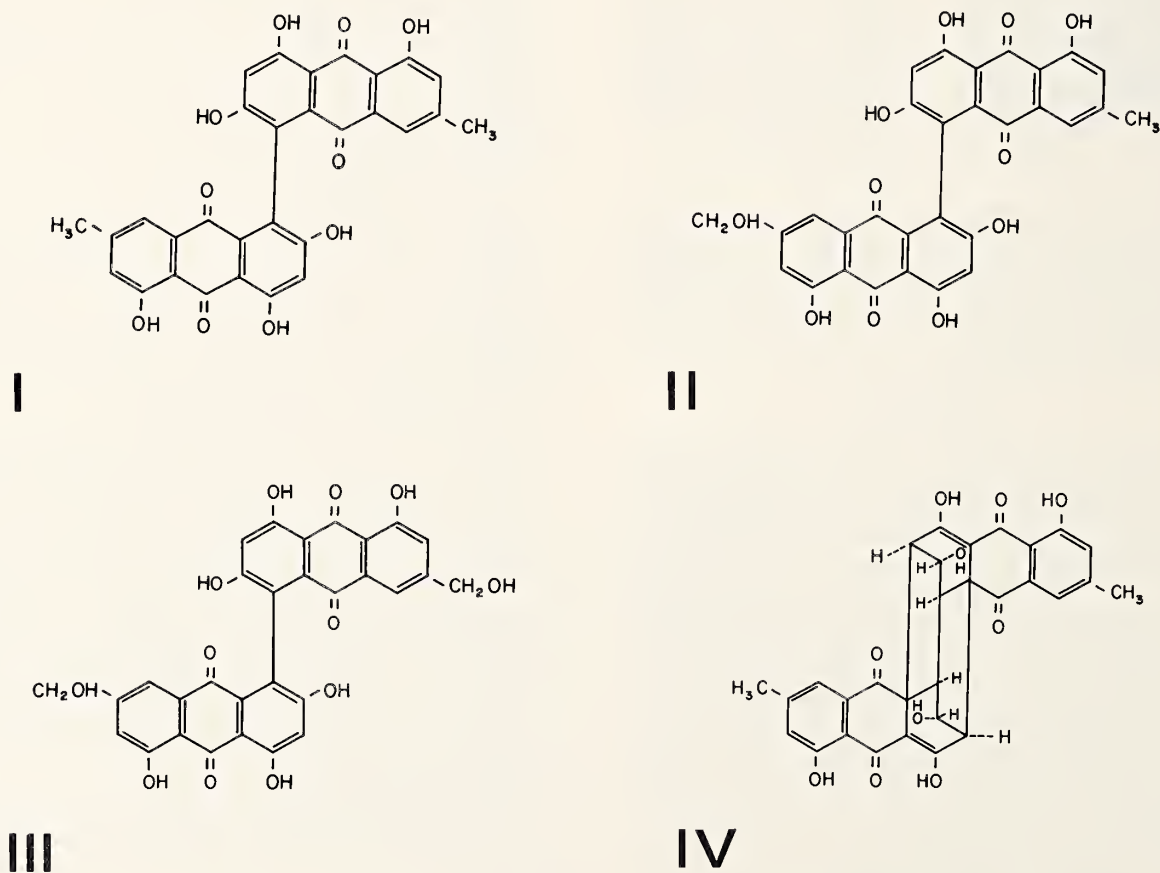


FIG. 1—Pigments in the fungal genus *Endothia*. I. Skyrin, II. Oxyskyrin, III. Skyrinol and IV. Rugulosin. (After Shibata)

(Schw.) Ces. and De Not. (= *E. fluens*), *E. gyrosa*, *E. havanensis* Bruner, *E. japonica* Kobayashi & Ito, *E. longirostris*, *E. macrospora* Kobayashi & Ito, *E. parasitica*, *E. singularis*, *E. tropicalis* and *E. viridistroma*. (See Tables 1 and 2 for cultures and specimens used.) Cultures were grown on white corn meal medium (5 g white corn meal: 30 ml distilled H<sub>2</sub>O per petri plate) for two weeks at room temperature. The mycelium then was separated from the remaining corn meal, dried and weighed. Reagent grade absolute ethanol was used to extract the pigments from the dried mycelium or stromal tissue. Fifty  $\mu$ l of 10<sup>-5</sup> dilutions of pigment extract were spotted on Eastman Chromagram 6061 silica gel sheets. The developer used was glacial acetic acid and ethyl acetate (1:20, V:V) under chamber-saturated conditions (Greenhalgh and Whalley, 1970). Standard solutions of skyrin, oxyskyrin and rugulosin were also run. The chromatograms were read under uv light at 254 nm. The orange spots were treated with concentrated H<sub>2</sub>SO<sub>4</sub> to test for the presence of skyrin which gives a deep cherry red color and then becomes emerald green (Shibata et al., 1955c). Oxyskyrin and skyrinol turn purple, then emerald green in concentrated H<sub>2</sub>SO<sub>4</sub> (Shibata et al., 1955d).

### Results and Discussion

Although much of the work clarifying the chemistry and biosynthesis of the anthraquinone pigments has been done with *Penicillium* spp., Shibata et al. (1955b) reported the occurrence of skyrin and rugulosin in *E. parasitica* and *E. fluens*. Later oxyskyrin was found in *E. parasitica* (Shibata et al., 1957), and Shibata (1967) noted that "skyrin occurs in various moulds, usually with rugulosin. Only one exception has been found: *P. islandicum* produces skyrin as a basic metabolite without rugulosin." Briggs and LeQuesne (1965) found skyrin in *E. longirostris* as well as a small amount of skyrinol in one culture of this taxon. Only skyrin occurred in their cultures of *E. tropicalis*. In *E. gyrosa* (CBS 113.13, Clinton's culture) they found skyrin and rugulosin. Results of the present studies are listed in Tables 1 and 2.

*Endothia parasitica*—In our cultures of *E. parasitica* we found skyrin, oxyskyrin, and rugulosin as did Shibata and his co-workers. The hypovirulent strain H' and CBS 242.52 (*E. parasitica* series luteostroma, Orsenigo) also contained these three pigments, but CBS 247.54 (*E. parasitica* series xanthostroma, Orsenigo) contained only skyrin and a small amount of rugulosin.

*Endothia radicalis*—The European and New Zealand isolates of *E. radicalis* (= *E. fluens*) (CBS 238.54, Biraghi; CBS 239.54, Orsenigo; PDD 30873 and PDD 31874, Samuels) contained only skyrin while the American isolates (CBS 116.13, P. J. Anderson; CBS 117.13, Clinton) contained skyrin, oxyskyrin and rugulosin. In contrast, Shibata et al. (1955b) reported the presence of skyrin and rugulosin in their cultures of *E. radicalis*.

*Endothia gyrosa*—The 26 cultures of *E. gyrosa* isolated from various American trees all contained skyrin, oxyskyrin, and rugulosin in contrast to CBS 113.13 (*E. gyrosa*, Clinton), CBS 250.54 (*E. gyrosa*, series xanthostroma, Orsenigo) and CBS 253.54 (*E. gyrosa*, series luteostroma, Orsenigo), which we found to contain only skyrin although Briggs and

TABLE 1  
*Anthraquinone pigments in cultures of Endothia species.*

Species	Roane and Stipes Accession	Sky-rin	Oxy-sky-rin	Sky-rinol	Rugulosin
<i>E. eugeniae</i> <i>E. gyrosa</i>	E-62 = IMI 44945	— <sup>a/</sup>	—	—	—
	E- 2 = FP94163	+ <sup>a/</sup>	+	—	+
	E- 3 = FP97482-R	+	+	—	+
	E-13	+	+	—	+
	E-18	+	+	—	+
	E-19	+	+	—	+
	E-20	+	+	—	+
	E-21	+	+	—	+
	E-22 = CBS 508.76	+	+	—	+
	E-32	+	+	—	+
	E-27	+	+	—	+
	E-28	+	+	—	+
	E-29 = ARA Mear 156	+	+	—	+
	E-30	+	+	—	+
	E-31	+	+	—	+
	E-32	+	+	—	+
	E-33	+	+	—	+
	E-34	+	+	—	+
	E-35	+	+	—	+
	E-36	+	+	—	+
	E-37	+	+	—	+
	E-38	+	+	—	+
	E-47	+	+	—	+
	E-48	+	+	—	+
	E-50	+	+	—	+
	E-51	+	+	—	+
	E-55	+	+	—	+
	E-14 = CBS 165.32	+	+	—	+
	E-83 = CBS 250.54	+	—	—	—
	E-84 = CBS 253.54	+	—	—	—
	E-90 = CBS 113.13	+	—	—	—
<i>E. havanensis</i> <i>E. japonica</i>	E-40 = CBS 505.63	+	+	—	+
	E-53 = Kobayashi E-49	+	—	—	+
<i>E. macrospora</i> <i>E. parasitica</i>	E-59	+	—	—	+
	E-54 = Kobayashi E-55	+	+	—	+
<i>E. radicalis</i>	E- 1 = 198/929 True	+	+	—	+
	E- 4 Strain "A" Berry & Day	+	+	—	+
	E- 7	+	+	—	+
	E- 8	+	+	—	+
	E- 9	+	+	—	+
	E-11	+	+	—	+
	E-12	+	+	—	+
	E-24	+	+	—	+
	E-25	+	+	—	+
	E-39	+	+	—	+
	E-43	+	+	—	+
	E-44	+	+	—	+
	E-45	+	+	—	+
	E-46	+	+	—	+
	E-49	+	+	—	+
	E-86	+	+	—	+
<i>E. singularis</i> <i>E. tropicalis</i>	E-94 Ep 43 H'	+	+	—	+
	E-78 CBS 242.54	+	+	—	+
	E-80 CBS 244.54	+	—	—	+
	E-16 CBS 238.54	+	—	—	—
<i>E. viridistroma</i>	E-75 CBS 239.54	+	—	—	—
	E-64 PDD 308.73	+	—	—	—
	E-67 PDD 31874	+	—	—	—
	E-91 CBS 116.13	+	+	—	+
<i>E. singularis</i> <i>E. tropicalis</i>	E-92 CBS 117.13	+	+	—	+
	E-58	+	—	—	—
	E-57 FD 135/62	+	—	—	—
<i>E. viridistroma</i>	E-70 PDD 326.19	+	—	—	—
	E-41 CBS 202.36	—	—	—	+

<sup>a/</sup> + indicates presence and — absence of the pigment.



TABLE 2  
Anthraquinone pigments in stromata of *Endothia* species.

Species	Specimen designation	Sky- rin	Oxy- sky- rin	Sky- rinol	Rugu- losin
<i>E. coccolobii</i>	Whetzel, Bermuda Fungi 147 (TYPE)	- <sup>a/</sup>	+ <sup>a/</sup>	-	+
<i>E. eugeniae</i>	IMI 45440	-	-	-	-
<i>E. gyrosa</i>	E-22	+	+	-	+
<i>E. havanensis</i>	Bruner 740 (TYPE)	+	-	-	-
<i>E. japonica</i>	Kobayashi 1049	+	-	-	+
<i>E. longirostris</i>	Earle 4340 (TYPE)	+	-	-	-
<i>E. singularis</i>	LaVeta, Colorado 1911	+	-	-	-
	Hawksworth, 1974 = E-58	+	-	-	-
<i>E. tropicalis</i>	USDA-BPI 2807, Petch (TYPE)	+	-	-	-
	Dingley 18377	+	-	-	-
<i>E. viridistroma</i>	Wehmeyer 3634 (TYPE)	-	-	-	+

<sup>a/</sup> + indicates presence and - absence of the pigment.

LeQuesne (1965) found skyrin and rugulosin in CBS 113.13.

*Endothia longirostris*—Briggs and LeQuesne found only skyrin in their cultures of *E. longirostris* except for one that also contained a small amount of skyrinol; we found only skyrin in the type collection (Heller, #4340, described by Earle).

*Endothia tropicalis*—Our finding of skyrin as the sole pigment in *E. tropicalis* agreed with that of Briggs and LeQuesne.

*Endothia havanensis*—Material from the type collection (#740, Bruner) of *E. havanensis* contained only skyrin while the culture, CBS 505.63, proved to have skyrin, oxyskyrin, and rugulosin. Because of this discrepancy between the pigment content of the type specimen and that of the culture CBS 505.63, there is a need for more material of this species for further study.

The information in Tables 1 and 2 on content of anthraquinone pigments in *E. coccolobii*, *E. eugeniae*,

*E. havanensis*, *E. japonica*, *E. macrospora*, *E. singularis* and *E. viridistroma* is reported for the first time. Since only skyrin was found in *E. havanensis* (type specimen), *E. longirostris* (type specimen), *E. singularis* and *E. tropicalis*, these taxa should be included with *P. islandicum* as fungi which produce skyrin in the absence of rugulosin. *Endothia eugeniae* presents a puzzle, since none of the anthraquinonic pigments is present and it is the only member of the genus with ovoid conidia.

The discrepancies in pigment content noted for *E. gyrosa*, *E. parasitica*, and *E. radicalis* may be due to the confusion regarding these taxa in the period of the rapid spread of the chestnut blight. W. G. Farlow (1912) discussed the macroscopic similarity of specimens named *E. gyrosa* and *E. radicalis* with what was then known as *Diaporthe parasitica* Murr. Clinton (1912) also reported finding *E. gyrosa* on chestnut and oak in the south as "a languishing parasite or as a saprophyte usually at the base or on the roots of the trees, and was never found forming isolated cankers on the otherwise sound sprouts." He thought this fungus to be the same as the so-called *E. gyrosa* on the same European hosts, but did not include it to be *E. parasitica*. It may well be that his culture deposited as CBS 113.13 (*E. gyrosa*) belongs to the taxa included in present-day *E. radicalis*, and his culture CBS 117.13 (*E. radicalis*) and Anderson's culture CBS 116.13 (*E. radicalis*) belong to the taxa included in present-day *E. gyrosa*. If this proves true, then there will be no discrepancies in pigment content of these taxa.

Pigment content in the *Endothia* spp. tested in the present study is summarized in Table 3. Each of the three species having one-celled ascospores, *E. gyrosa*, *E. singularis* and *E. viridistroma*, have distinct pigment complements. The nine species having two-celled ascospores fall into five groups according to pigment content, but taxa within most of these groups can be separated by morphologic characters. At this point, quantitative differences in pigment production have not been investigated nor has the value of quantitative differences in pigment production been established as a tool for species separation.

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### Literature Cited

- Alston, R. E., and Turner, B. L. (1963): Biochemical Systematics, 404 pp., Prentice-Hall, New Jersey.  
Anderson, P. J. (1913): The Morphology and Life History of the

TABLE 3  
Summary of pigment content of *Endothia* species.

	Skyrin	Oxy- skyrin	Sky- rinol	Rugu- losin
Section a. 1-celled ascospores				
<i>E. gyrosa</i>	+ <sup>a/</sup>	+	-	+
<i>E. singularis</i>	+	-	-	-
<i>E. viridistroma</i>	-	-	-	+
Section b. 2-celled ascospores				
<i>E. coccolobii</i>	-	+	-	+
<i>E. eugeniae</i>	-	-	-	-
<i>E. havanensis</i>	+	-	-	-
<i>E. radicalis</i>	+	-	-	-
<i>E. tropicalis</i>	+	-	-	-
<i>E. japonica</i>	+	-	-	+
<i>E. longirostris</i>	+	-	-	-
<i>E. macrospora</i>	+	+	-	+
<i>E. parasitica</i>	+	+	-	+

<sup>a/</sup> + indicates presence and - absence of pigment.

- Chestnut-Blight Fungus. Bull. Penn. Chestnut Tree Blight Comm. 7, 1-43.
- Binns, W. W., and Blunden, G. (1969): Effects of Hybridization on Leaf Constituents in the Genus *Salix*. Phytochem. 8, 1235-1239.
- Boerboom, J. H. A., and Maas, P. W. T. (1970): Canker of *Eucalyptus grandis* and *E. saligna* in Surinam Caused by *Endothia havanensis*. Turrialba 20, 94-99.
- Breen, J., Dacre, J. C., Raistrick, H., and Smith, G. (1955): Studies in the Biochemistry of Micro-organisms. 95. Rugulosin, a Crystalline Coloring Matter of *Penicillium rugulosum* Thom. Biochem. J. 60, 618-626.
- Briggs, L. H., and LeQuesne, P. W. (1965): Chemistry of Fungi, Part II: Constituents of Three *Endothia* Species. J. Chem. Soc. 2290-2291.
- Clinton, G. P. (1912): Some Facts and Theories Concerning Chestnut Blight. Penn. Chestnut Blight Conf. Proc., pp. 75-83. Penn. Chestnut Tree Blight Comm., Harrisburg, 254 pp.
- Crawford, Daniel J. (1972): The Morphology and Flavonoid Chemistry of Synthetic Intraspecific Hybrids in *Coreopsis nutica* (Compositae). Taxon 21, 27-38.
- Farlow, W. G. (1912): Botanical History of *Diaporthe parasitica* and Allied or Identical Fungi. Penn. Chestnut Blight Conf. Proc., pp. 70-75. Penn. Chestnut Tree Blight Comm., Harrisburg, 254 pp.
- Fries, E. M. (1849): Summa Vegetabilium Scandinaviae. Sect. 2. Upsaliae.
- Gatenbeck, S. (1960): Studies on the Biosynthesis of Anthraquinones in Lower Fungi. Svensk. Kimisk Tidskrift 72, 188-203.
- Greenhalgh, G. N. and Whalley, A. J. S. (1970): Stromal Pigments of Some Species of *Hypoxylon*. Trans. Br. Mycol. Soc. 55, 89-96.
- Hawkins, Lon A. and Stevens, Neil E. (1917): *Endothia* Pigments I. Amer. J. Bot. 4, 336-353.
- Howard, B. H., and Raistrick, H. (1954): Studies in the Biochemistry of Micro-organisms. 91. The Colouring Matters of *Penicillium islandicum* Sopp. Part III. Skyrin and Flavoskyrin. Biochem. J. 56, 56-65.
- Levin, D. A. and Schaal, B. A. (1970): Reticulate Evolution in *Phlox* as Seen Through Protein Electrophoresis. Amer. J. Bot. 57, 977-987.
- Nutman, F. J., and Roberts, F. M. (1952): Acute Die-Back of Clove Trees in the Zanzibar Protectorate. Ann. Appl. Biol. 39, 599-608.
- Pantanelli, E. (1911): Sul parassitismo di *Diaporthe parasitica* Murr. per il castagno. Accademia Nazionale Dei Lincei. Rome Rendiconti Classe Di Scienze Fisiche. Italy. 20, 366-372.
- Roane, Martha K. and Stipes, R. Jay (1976): The Fungal Genus *Endothia* in the Southern Appalachians. In: Distributional History of the Biota of the Southern Appalachians. Part IV. Algae and Fungi, pp. 227-242, University Press of Virginia, Charlottesville.
- Sando, Charles E. (1919): *Endothia* Pigments II Endothine Red. Amer. J. Bot. 6, 242-251.
- Schweinitz, L. D. von. (1822): Synopsis Fungorum Carolinae Superioris. Leipzig, 105 pp.
- Shear, C. E., Stevens, N. E., and Tiller, R. J. (1917): *Endothia parasitica* and Related Species. U. S. Dept. Agr. Bull. 380. 82 pp.
- Shibata, S. (1967): Chemistry and Biosynthesis of Some Fungal Metabolites. Chemistry in Britain, 110-121.
- Shibata, S. (1973): Some Recent Studies on the Metabolites of Fungi and Lichens. Pure and Appl. Chem. 33, 109-128.
- Shibata, S. and Ikekawa, T. (1963): Metabolic Products of Fungi XX. The Biosynthesis of Rugulosin. Chem. Pharm. Bull. Tokyo 11, 368-372.
- Shibata, S., Murakami, T., Tanaka, O., Chihara, G., Kitagawa, I., Sumimoto, M., and Kaneko, C. (1955a): The Respective Identities of Endothianin and Radicalisin with Skyrin and Rugulosin; and the Structure of Skyrin. Chem. Pharm. Bull. Tokyo 3, 160-161.
- Shibata, S., Murakami, T., Tanaka, O., Chihara, G., and Sumimoto, M. (1955b): Metabolic Products of Fungi. IV. Isolation of the Coloring Matters of *Endothia* spp. and the Respective Identities of Endothianin and Radicalisin with Skyrin and Rugulosin. Chem. Pharm. Bull. Tokyo 3, 272-277.
- Shibata, S., Takido, M., and Nakajima, T. (1955c): Metabolic Products of Fungi. VII. Paper Chromatography of the Coloring Matters of *Penicillium islandicum* Sopp. Chem. Pharm. Bull. Tokyo 3, 286-290.
- Shibata, S., Takido, M., Ohta, A., and Kurosu, T. (1957): Metabolic Products of Fungi. V. The Structure of Skyrin. Chem. Pharm. Bull. Tokyo 3, 278-283.
- Shibata, S., Tanaka, O., Chihara, G., and Mitsuhashi, H. (1953): On the Coloring Matter Produced by *Endothia parasitica* Fr. and *Endothia radicalis* Fr. Chem. Pharm. Bull. Tokyo 1, 302-304.
- Shibata, S., Tanaka, O. and Kitagawa, I. (1955d): Metabolic Products of Fungi. V. The Structure of Skyrin. Chem. Pharm. Bull. Tokyo 3, 278-283.
- Tyrrell, D. (1969): Biochemical Systematics and Fungi. Bot. Rev. 35, 305-316.
- Wehmeyer, L. E. (1936): Cultural Studies of Three New Pyrenomycetes. Mycologia 28, 23-46.

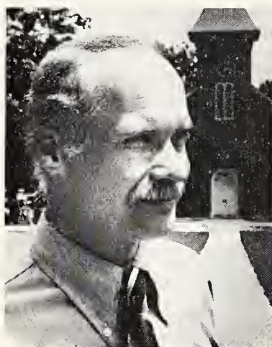


# Retrieval in Human Memorization

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**Abstract**—Two experiments involving human memorization are reported. The first study showed that rehearsal influences retrieval of memorized information and that simple, rote rehearsal benefits retention over the short term, while elaborate, integrative rehearsal benefits retention over the long term. The second study indicated that the efficacy of distributed practice results from practicing difficult retrieval during memorization. The theoretical and practical implications of these data are discussed.

## Introduction

Folk wisdom has yielded many homilies about human memory, and our everyday experience has provided some support for these adages. Does "Practice make perfect?" Not always, unfortunately, but we do know that chanting "Thirty days hath September. . ." and using other mnemonic devices such as "Every good boy does fine" often help us remember large amounts of verbal information.

An understanding of these folk laws of memory will have both practical and theoretical benefits. From a practical standpoint, the ability to efficiently and accurately retain information has self-evident utility as every student knows. From the standpoint of experimental psychology, explication of the mechanisms that underlie retention will permit the development of a more adequate theory of memory. To these ends, the work reported below attempts to elucidate the roles of practice and rehearsal in memorization that occurs under controlled laboratory conditions.

The specific issues considered in the present report may be summarized as follows: (a) What are the characteristics of effective rehearsal (mnemonic) techniques and why do they work? We already know that retention suffers when we simply repeat or superficially analyze to-be-remembered events (Elmes and Bjork, 1975). On the other hand, elaborate rehearsal or complex analysis, such as the rough and ready

mnemonics noted above, can have a strong positive effect on memory (Elmes and Thompson, 1977). So, we need to specify how different types of rehearsal have their effect on retention. (b) Under what conditions is practice maximally beneficial? According to previous work (e.g., Elmes and Bjork, 1975; Thios and D'Agostino, 1976), the effectiveness of practice typically increases as the interval separating successive practices increases. Since the generality of this result (usually called the spacing effect) is practically important, and since its theoretical interpretation is currently moot, further work seems warranted.

The theoretical framework of the present studies is the tripartite view of human learning and memory first proposed by Köhler (1947) and subsequently explicated by Melton (1963). According to Melton, the learner/memorizer first acquires information, then stores it for retention, and then is able to retrieve or use that information. Nearly all laboratory work concerned with rehearsal and practice has focused on the acquisition and storage phases of information processing. The lack of emphasis on retrieval processes is incongruous, because we can only study memory when retrieval can occur. Furthermore, in everyday situations retrieval of acquired and stored information is the "bottom line" as far as the learner and his evaluators are concerned. These general criticisms receive support from laboratory and introspective analyses, indicating that the act of retrieval itself is an important determiner of the viability of retention (e.g., Roediger, 1978; Thios and D'Agostino, 1976). Thus, the present experiments constitute a series designed to converge on the issues outlined above. In very general terms, the concern is about the role of retrieval processes in the effects of rehearsal and practice conditions on retention.

## Experiment I

**Introduction.**—In Experiment I we will try to determine if different types of rehearsal have their effects on acquisition and storage or if they have primary influence on retrieval.

In order to examine the possible effects of rote and elaborative rehearsal on retrieval, a task developed by Bjork and Whitten (1974) was used. In their task to-be-free-recalled, items are separated from each other during presentation by an extensive amount of distracting mathematical activity. In this task they obtained a standard bowed serial-position-curve, wherein retention is best for the beginning and end items and worst for the middle ones. So, they rea-

soned that the curve resulted from long-term retrieval processes and not differential acquisition or storage, which the distracting task should have made equivalent for all items regardless of serial position. Therefore, if in the present experiment different types of rehearsal have different effects on the shape of the serial position curve in the Bjork and Whitten paradigm, it can be concluded that rehearsal has its major effects on the retrieval of information.

**Method.**—In a  $2 \times 2 \times 10$  mixed factorial design, 40 male undergraduate volunteers free recalled 2 lists comprised of 10 word triads after receiving either rote rehearsal instructions (half the subjects were told to simply repeat aloud each triad over and over as long as it was on the screen in front of them) or elaborative rehearsal instructions (the other half of the subjects were told to integrate or combine the words in a triad in some meaningful way, such as grouping them in the same sentence). One list was composed of high-imagery words (e.g., *gentleman*, *letter*, *hurdle*), and the other list consisted of low imagery words (e.g., *rating*, *hypothesis*, *chance*). The order of presenting the two lists was counterbalanced across subjects, and the input serial position of each word triad was counterbalanced across subjects. Each word triad appeared on a screen for 5.5 seconds. A slide containing 54 numbers preceded and followed each triad, and the subjects were required to say these digits out loud as rapidly as possible during the entire 11 seconds that the digits appeared on the screen. A Kodak Carousel projector and automatic timer presented the materials. At the end of each list, the subjects had unlimited time to write as many of the words that they could remember in any order they wished.

**Results and Discussion.**—The serial position curves for total recall are shown in the bottom panels of Figure 1. As expected, high imagery words were recalled better than low imagery words, elaborative rehearsal led to better retention than did rote rehearsal, and neither variable influenced the order in which the items were recalled (see Elmes and Bjork, 1975). Not shown in the figure is the rehearsal  $\times$  imagery interaction, in which recall was best for high imagery words under elaborate rehearsal.

The effects of the two types of rehearsal on the shapes of the serial position curves are best seen in the upper right-hand panel. The upper panels represent normalized functions obtained by dividing the number recalled at a particular serial position by the total recall in that condition. This normalizing procedure takes account of differential levels of recall among conditions and allows a direct examination of the shapes of the curves (Harcum, 1968). Notice that there is a strong primacy effect favoring elaborative rehearsal for triad position 1,  $t(38) = 1.73$ ,  $p < .05$ , and there is a strong recency effect in favor of rote rehearsal for triad position 10,  $t(38) = 2.79$ ,  $p < .005$ . Since the shapes of the serial position curves differed under the two types of rehearsal in a situation designed to minimize differences in acquisition and storage, it may be concluded that the primary function of rehearsal is a change in the accessibility (i.e., retrievability) of memorized information. In the present situation, rote rehearsal resulted in more accurate short-term retrieval than did elaborative rehearsal

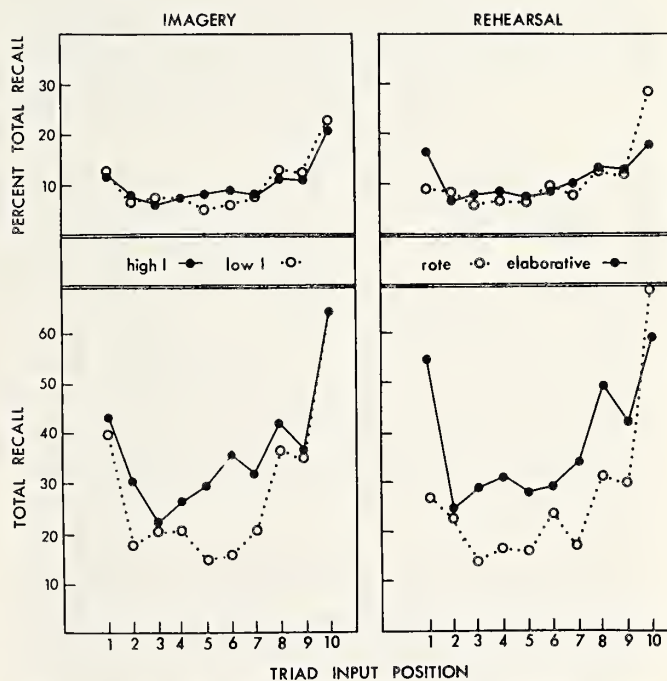


FIG. 1.—Total recall (lower panels) and percent total recall (upper panels) as a function of the serial presentation position of each word triad in Experiment 1.

(the strong recency effect in Figure 1). On the other hand, more accurate long-term retrieval occurred with elaborative than with rote rehearsal (the strong primacy effect in Figure 1).

## Experiment II

**Introduction.**—The highly reliable and general finding that retention improves in a negatively accelerated fashion as a function of the interval separating successive practices (the *spacing effect*) usually has been attributed to changes in acquisition or storage that occur as the repetition interval increases. The acquisition and storage theories have not been very successful in accounting for the spacing effect (e.g., Elmes and Bjork, 1975; Thios and D'Agostino, 1976), so it makes sense to examine the possibility that retrieval processes may play a role in determining improvements in recall across increasing spacing intervals.

Retrieval may be an important determiner of the spacing effect for two reasons (see Thios and D'Agostino, 1976): (a) in the first place, retrieval of information about the first occurrence of an item should increase in difficulty as the spacing interval increases, which means that the learner would have some practice during his study of the kinds of retrieval necessary for accurate recall at the time of test; (b) in the second place, the increasingly difficult retrieval of first-occurrence information across repetition intervals might force the subject during memorization to think more about the to-be-remembered items than when repetitions occur close together in time and yield easy retrieval of first-occurrence information.



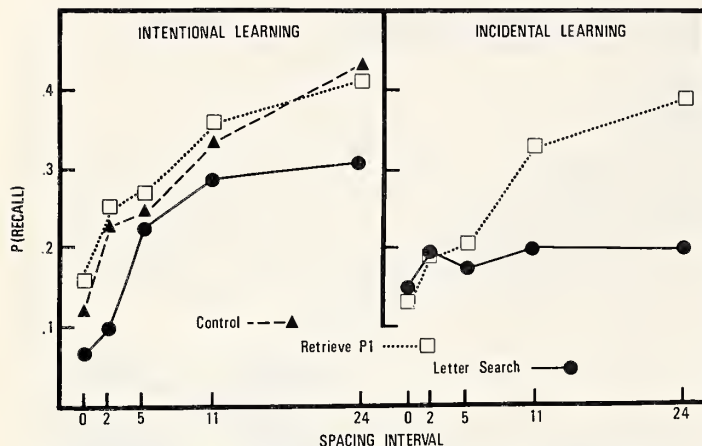


FIG. 2.—Proportion of words free recalled as a function of the interval between two presentations of a word in Experiment II.

To test the role of retrieval in the spacing effect, the Bjork and Whitten (1974) task used in Experiment I was also used in Experiment II. Remember, the separation of items by distracting activity minimizes differential acquisition and storage processes. So, with items repeated at various spacing intervals in such a paradigm, differences in recall should be due, primarily, to differences in retrieval. Further assurance that differential acquisition and storage processes were minimized in Experiment II was effected by having some subjects recall the material after having been presented the material without forewarning of a recall test (so-called incidental learning). The incidental-learning subjects were either required to focus on each word as it was presented, or they had to look back in memory and try to retrieve information as to whether or not that word had been presented before. So, if retrieval is important in practice, the latter incidental group but not the former should show a spacing effect in recall.

**Method.**—The 100 male undergraduate volunteers heard and then free recalled 20 target words. Equal numbers of these words were repeated at intervals of 0, 2, 5, 11, and 24 list events. Filler words began and ended each list. Across subjects each target word was tested at each spacing interval according to a balanced Latin square procedure. Preceding and following each word were two-digit numbers, and the subjects wrote down whether these numbers were odd or even. They had 1.5 seconds to write the judgments for both numbers.

The subjects were randomly and evenly assigned to one of five independent groups. Three of these groups were the intentional-learning groups: subjects received instructions telling them to classify the digits and try to remember the words. In the Letter Search condition, the subjects had to write down whether each word contained an "M," a "T," or neither of those letters; in the Retrieve P1 condition, the subjects had to write down for each word whether it was the first or second time that they had heard that word.

The two incidental-learning groups received instructions similar to the Letter Search and Retrieve P1 conditions. However, the incidental-learning subjects thought they were judging materials for sub-

sequent experiments, and they were not forewarned about the free-recall test at the end of the list.

**Results and Discussion.**—Only 0.4 percent errors of letter detection occurred in the Letter Search conditions. The letter detection errors were unrelated to spacing interval and type of learning instruction. Correctly judging that the second occurrence of a word was indeed the second occurrence decreased in ease across spacing intervals. No errors occurred at spacing intervals of 0 or 2, 3.7 percent errors occurred at interval 5, 5.6 percent occurred at interval 11, and 16.9 percent occurred at interval 24. The error rate was similar for both the incidental and intentional learning conditions. These error data indicate two things: (1) the Letter Search task was successful in forcing the subjects to carefully attend to each word as it was presented; and (2) the difficulty of correctly retrieving information about the first occurrence of a word increased markedly with increases in the spacing interval.

The recall results of Experiment II are shown in Figure 2. As expected, the spacing effect did not occur in the Letter Search Group that had incidental learning instructions:  $F < 1$ . However, there was a strong spacing effect in the Retrieve P1 Group that had incidental instructions:  $F(4,76) = 6.76, p < .001$ . Note that the Letter Search task attenuated somewhat the spacing effect for the intentional learning subjects.

It can be concluded that retrieval of first-occurrence information plays an important role in determining the effects of practice. Since these retrieval effects are so strong in incidental learning, it is likely that retrieval during study benefits subsequent recall by allowing the learner to practice the sort of retrieval that is a requisite for good retention performance.

## Discussion

A few theoretical conclusions seem warranted. The present results highlight the importance of retrieval in retention. Rote and elaborative rehearsal have a strong influence on retrieval processes, and it appears that the effectiveness of distributed practice comes about because of the way in which retrieval is practiced during learning. These results and others (e.g., Roediger, 1978) suggest that an understanding of how retrieval works will allow a clearer understanding of how our memory operates. It may be that laboratory studies of memory have focused on the mechanisms of acquisition and storage to the detriment of an understanding of the mechanisms of retrieval. In any event, the present results clearly show that long-term accessibility is enhanced by elaborate rehearsal, and that rote rehearsal can improve short-term retrieval.

The above conclusion leads to some practical considerations. The results of Experiment I suggest that the type of study or rehearsal should be tailored to the utilization demands (conditions of retrieval) placed upon the learner. We know only too well that efficiency in memorization is a difficult task. If information is needed only relatively briefly, then rote rehearsal should be undertaken. However, longer-

term retention will be better served by elaborative rehearsal.

The results of Experiment II have two important practical implications, one well-known and one not so well known. In the first place, distributed or highly spaced practice results in much better retention than does massed practice. Since this highly reliable effect seems to result from practicing difficult retrieval, the second implication needs to be described in some detail. If good retention results from practicing difficult retrieval, then it does not make much sense to allow most learning to occur under conditions of easy retrieval. Nevertheless, many aspects of curriculum content, course planning, and textbook design have been implemented precisely because easy retrieval is required. The basis of most teaching machines, self-paced courses, and programmed textbooks is to present small units to be learned with minimal frustration (i.e., very easy retrieval). While the easy retrieval may attenuate some motivational problems, the present data as well as some other results (Bjork, 1975) indicate that easy retrieval may accentuate poor retention.

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#### Literature Cited

- Bjork, R. A. (1975): Retrieval as a Memory Modifier: an Interpretation of Negative Recency and Related Phenomena. In *Information Processing and Cognition* (R. L. Solso, ed.), pp. 123-144, Erlbaum, New Jersey.
- Bjork, R. A. and Whitten, W. B. (1974): Recency-Sensitive Retrieval Processes in Long-Term Free Recall. *Cog. Psychol.* **6**, 173-189.
- Elmes, D. G. and Bjork, R. A. (1975): The Interaction of Encoding and Rehearsal Processes in the Recall of Repeated and Non-Repeated Items. *J. Verb. Learn. Verb. Behav.* **14**, 30-42.
- Elmes, D. G. and Thompson, J. B. (1977): Attenuating the Effects of Different Levels of Processing: the Role of Cue Position and Cue/Word Interval. *Bull. Psychon. Soc.* **10**, 152-154.
- Harcum, E. R. (1968): A Note on "Encoding in the Perceptual (Visual) Serial Position Effect." *J. Verb. Learn. Verb. Behav.* **7**, 275-277.
- Köhler, W. (1947): *Gestalt Psychology*, Ch. 9, Liveright, New York.
- Melton, A. W. (1963): Implications of Short-Term Memory for a General Theory of Memory. *J. Verb. Learn. Verb. Behav.* **2**, 1-21.
- Roediger, H. L. (1978): Recall as a Self-Limiting Process. *Mem. & Cog.* **6**, 54-63.
- Thios, S. and D'Agostino, P. R. (1976): Effects of Repetition as a Function of Study-Phase Retrieval. *J. Verb. Learn. Verb. Behav.* **15**, 529-536.



# Potential of Summer Rain Augmentation by Cloud Seeding in the Mid-Atlantic States

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The first evaluatory step is the application of a one-dimensional computer model cloud to the radiosonde(s) characterizing the environment to calculate the frequency of "seedability," namely the amount the vertical cloud growth might be enhanced by dynamic seeding, provided suitable clouds were in fact present. The model was applied to 1225 radiosonde observations for Dulles Airport, Virginia, from May through August, 1972-1976. Seedability was found on more than half the soundings, increasing in frequency from May to midsummer. Radar, satellite, and rainfall data were analyzed to eliminate showerless situations and to flag naturally high rainy conditions which might not be suitable for seeding. Only 23 percent of seedable cases was definitely eliminated by absence of shower echoes. Opportunity estimates are compared with seeding cases obtained during a first experimental year in 1978 in Delaware.

In conclusion, the first criteria have been passed, and the next more difficult steps in assessing seeding potential are outlined.

## Introduction

A report assessing world-wide weather modification potential has just been published by a panel appointed by the Secretary of Commerce (Cleveland et al., 1978). High priority and benefit potential was assigned to a rain augmentation hypothesis called "dynamic cumulus seeding." The major basis for this projection was early results from an exploratory double-blind experiment recently completed in south Florida (Woodley et al., 1978a). If confirmed, results of the Florida Area Cumulus Experiment (FACE 1) suggest that it may be possible to economically increase rainfall from some of the cumulus cloud systems which produce most of the precipitation during the summer growing season over much of the United States. The seeding concept, altering the dynamics and interaction of the clouds by massive silver iodide seeding, was evolved from a computer simulation of cumulus processes developed by the senior author beginning in the early 1960's (Malkus and Simpson, 1964; Simpson et al., 1965).

The underlying physical concept is that the rapid conversion to ice of a supercooled water cloud releases latent heat in large quantities, increasing the

**Abstract**—The first phase of a feasibility assessment of summer rain augmentation potential by so-called "dynamic seeding" is reported for the mid-Atlantic region. Dynamic seeding involves enhancing cumulus cloud growth and merger by massive silver iodide injections, usually by airborne pyrotechnic flares. Larger, longer-lived cloud systems have been shown to produce more rainfall. A dynamic seeding experiment in Florida has entered its confirmatory phase, from which necessary criteria for application to other areas have been developed, although sufficient conditions for success are still not known.

buoyancy of the cloudy air so that, under predictable conditions, the seeded clouds will experience more growth than if left unseeded. This is the cumulus modification approach that has been colloquially called "dynamic seeding." It is quite different from earlier-used glaciogenic seeding where the attempt is to increase the precipitation efficiency without regard to the clouds' dynamics.

The model and seeding concept was first tested by a series of statistically controlled experiments on individual clouds over the tropical Atlantic (Simpson, Brier, and Simpson, 1967). The experiments were moved to south Florida in 1968 when pyrotechnic flares were developed for producing the silver iodide smoke which could be safely dropped over land (Simpson et al., 1970). At that time the model was improved to include simulation of rain development and fallout (Simpson and Wiggert, 1969, 1971). The Florida single-cloud experiments confirmed that the dynamically invigorated seeded clouds grew taller, lasted longer and processed more water, thereby producing a rain volume double or triple that of their unseeded counterparts (Simpson et al., 1971). During the course of these experiments, however, it was learned that 90 to 95 percent of the rain on the relatively fair days suitable for the experiment falls not from single clouds, but from merged complexes of several clouds that have joined together to form a system (Simpson and Woodley, 1971).

Consequently, in order to design an experiment to determine whether area-wide rainfall can be increased by dynamic seeding, it was necessary to add the ingredient of cloud aggregation and merging into the experimental concepts and design. The Florida Area Cumulus Experiment (FACE I) of the Experimental Meteorology Laboratory<sup>1</sup> of the National Oceanic and Atmospheric Administration (NOAA) began in a  $1.3 \times 10^4$  km<sup>2</sup> target area in 1970 in cooperation with scientists from several universities. The exploratory field phase was completed in 1976 under the direction of Dr. W. L. Woodley. The main results of the experiment are reported by Woodley et al. (1978a, 1978b), with bibliographies covering the numerous interim publications on the varying aspects of the program, ranging from cloud and aerosol microphysics through seeding technology, modeling, instrument systems, multivariate statistics, and environmental impacts.

The principal relevant result of the exploratory experiment is that target rainfall was apparently about 20 percent greater on randomly selected seeded days than on randomly selected control days. This result has moderate statistical support. Days meeting the suitability criterion for experimentation, to be described later, comprise about one third of the rainy season days in south Florida, which produce about one-half the total seasonal rainfall. Thus, if the experimental approach can be confirmed and transferred to an operation, which is much less costly than an instrumented, evaluated and double-blind experiment, seasonal rainfall might be increased by 10 to 12 percent. That increase could be economically attractive, particularly if adequate water storage facilities and the seeding target can be collocated.

In the summer of 1978, the FACE entered its confirmatory phase, namely an optimal replication without design changes and with analysis procedures specified in advance. If the rain increases are confirmed, the question arises concerning the applicability of this seeding approach to rain augmentation in other regions. Research is already underway establishing the sequence of steps which must be taken in advance of a major area experiment (Simpson et al., 1977). Some of these initial researches are already complete and others are underway. In particular, plans are in progress for an experiment in central Illinois, to be entitled Precipitation Augmentation for Crops Experiment (PACE) (Illinois State Water Survey et al., 1978).

The central Atlantic states, often plagued by water shortages, might also be benefited by this seeding concept. This area has certain advantages for experimentation with dynamic seeding relative to the midwest. The first is the greater rarity of severe weather conditions such as hail and tornadoes, which may plague dynamic augmentation of cumulus clouds in the midwest and high plains regions. The second is absence of the midwest's nighttime secondary rain maximum, which requires frequent nocturnal operations.

The state of Delaware has suffered water shortages harming its agriculture during many growing seasons of the 1970's. As in Illinois, corn and soybeans are the primary crops involved. In 1977, officials of the Delaware Agricultural Experiment Station and the Delaware State Department of Agriculture arranged to cooperate with Simpson and colleagues at the University of Virginia to undertake the first step of a dynamic seeding feasibility study for the spring and summer seasons in Delaware. This paper reports the results of this first-step feasibility study. The results are deemed qualitatively applicable for the central Atlantic states, extending roughly from New Jersey to southern Virginia. As described later, special consideration of coastal areas is required.

### Sequential Tests for Applicability

Since the effectiveness of area-wide rain augmentation in Florida by dynamic seeding is still under confirmatory experimentation and since, furthermore, some of the physical linkages between the demonstrated cloud glaciation by seeding and the postulated areal increase of precipitation are not well understood, the sufficient conditions for transferability are not confidently specifiable at this time. However, a sequence of necessary conditions can be specified (Simpson et al., 1977; Simpson, 1978). If the cloud and environmental properties in the area fail to meet any one of these conditions, the effort and expense of proceeding to the next stage of research or experimentation is not warranted in terms of practical benefits.

The applicability tests subdivide into two categories, which are also sequential, namely:

1. Single cloud criteria and experimentation (if successful, proceed to step 2); and
2. Area-wide research followed by experiment design and execution. This involves cloud merger and complexes and mesoscale (10-100 km) processes.

<sup>1</sup> Now the National Hurricane and Experimental Meteorology Laboratory (NHEML).



*Single cloud research and experimentation*—The single cloud criteria are specified, with the necessary models, calculations, measurements and experimentation completed and described in several areas of the world (Simpson and Dennis, 1974). The area-wide phase is less advanced, because it is at least two orders of magnitude more difficult, involving cloud interactions and mesoscale (10–100 km) processes. There is controversy in the scientific community concerning the necessity of single-cloud experimentation prior to area-wide experimentation. These writers adhere to the conservative group advocating an orderly systematic progression in each location, at least until confirmation is achieved in one or two locations and transferability criteria are firmly specified.

The first (single-cloud) phase involves the following steps:

- a. One-dimensional, cumulus model calculations determining the distribution of dynamic "seedability," assuming that natural clouds of various sizes and internal properties are present. Dynamic seedability is defined (Simpson et al., 1967) as the difference in maximum top heights in kilometers between a seeded and unseeded cloud having the same environment and initial conditions. It has been demonstrated that model-calculated seedability is related directly to rain augmentation from dynamic seeding of single clouds (Simpson et al., 1971). Seedability is also a necessary condition for area-wide rain augmentation by this methodology.
- b. If dynamic seedability above about one km is present on an adequate fraction of growing season days, then cloud population studies should be undertaken. In Florida, there was some evidence of reduced or possibly even a slightly negative effect of dynamic seeding on days of a large-scale weather disturbance, in which most cumuli were raining naturally and extensive layer clouds were present (Simpson and Woodley, 1971). It is not presently clear that disturbed days would respond similarly in other areas, and this problem reemphasizes the need for single-cloud experimentation.

In south Florida, model calculations showed zero seedability on only 5 percent of summer days, while in Illinois it was zero on about 30 percent of the days. In tropical marine air masses, cloud population studies are best undertaken with a 5- or 10-cm weather radar with a height-finding capability. To be seedable by any type of glaciogenic seeding, cumulus tops should be in the height ranges where their temperatures range from 0° C to not colder than about –25° C. Before reaching the latter temperature, large concentrations of natural ice-forming nuclei are generally plentiful. If any form of silver iodide (AgI) is used as the nucleating agent, cloud tops must be in the range from about –8° C to –25° C, since most mixes of AgI are not very effective at temperatures above about –8° C.

In less tropical, more continental air masses where raindrops may not be present in clouds in this temperature range, useful population statis-

tics require a shorter wavelength radar, e.g. three cm as in Israel (Gagin and Neumann 1974). Generally the studies must be supplemented by combined photogrammetry, satellite studies and aircraft sampling.

Holle (1974) conducted a combined radar and model study of seedable cloud distributions in two 3500-km<sup>2</sup> areas near Tampa and Miami, Florida for April 16 to May 31, 1969 and 1970. The Tampa area had seedable tops for 12 percent of all possible hours in 1969 and 9 percent in 1970. The Miami area figures were 21 percent in 1969 and 10 percent in 1970. Experience has shown that, in the FACE target area (1.3 × 10<sup>4</sup> km<sup>2</sup>), clouds meeting the top temperature criterion can be found during daylight hours on more than two thirds of all days from May through September, except during extreme drought when the figure reduces to about one third (Simpson et al., 1972). Similar cloud population studies are underway for the PACE area in central Illinois.

- c. If good seedability and cloud tops in the desired temperature range coincide on 20 to 50 days during a season, the next step, namely aircraft measurement of key in-cloud properties, is probably warranted.

The most urgent measurement is the amount and time distribution of supercooled water present in the cloud drop-size range (up to about 40 μm-diameter). Determination of the existence and duration of the crucial "seeding window" is dependent upon this measurement, which fortunately can be obtained with relatively simple inexpensive equipment. Also desirable to document but much more difficult and expensive are the natural ice distributions, the particle spectra, and the concentration of ice and condensation nuclei which are apt to vary with air mass, cloud temperature profiles, and cloud history (Hallett et al., 1978).

- d. If supercooled water amounting to 0.5 to 1 g/m<sup>3</sup> (in the spectrum size range less than 40 μm in diameter) persists in most cloud tops in the specified temperature range for 2 to 3 minutes (or preferably longer) under conditions of good seedability, it is virtually certain that dynamic seeding will induce increased vertical cloud growth. A randomized single cloud experiment is now necessary for the following reasons: 1) to confirm whether, under what conditions, and how much dynamic seeding increases single-cloud precipitation; 2) to establish relations between rain augmentation at cloud base and at the ground; 3) to determine whether naturally rainy conditions should be excluded; and 4) to develop experience and systems for the area experiment to follow.
- e. If single-cloud rainfall is increased by a factor of 1.5 to 2, about 50 to 100 cases should be adequate to determine this at an acceptable level of statistical significance. Both the fractional and absolute increases must be examined to determine whether advancement to the area experiment is justified. Florida experience



shows a factor of 2.5 to 3 increase in single-cloud rainfall, a tentative factor of about 1.4 in the intensely seeded "floating target" cloud complexes in the area experiment and a tentative 1.2 area-wide increase on seed relative to control cases. Hence, if single-cloud rain increases are a factor less than about 1.5, the reduction expected when proceeding to an area would likely render area seeding uneconomically feasible. This conclusion is not firm, due to apparently much larger area-wide seeding effects on some days than others in Florida. However, even a factor of 2 to 3 increase in single-cloud rain in arid areas may not be economic either, since doubling or tripling a tiny number still yields a tiny number.

If the single-cloud experimentation is successful with promising economic estimates based on its outcome, the much more difficult and expensive step to area-wide research followed by experimentation can be taken. These phase 2 steps are not all definitive, owing to less adequate understanding of mesoscale processes. For that reason and also because this phase is far ahead of the results reported in this article, only a brief sketch of an area-wide program is outlined here.

**Area-wide research and experimentation**—a. The essential mesoscale modeling effort is well underway from other motivations. The first is the adaptation of the University of Virginia three-dimensional, time-dependent, seabreeze model developed by Pielke (1974; Pielke and Mahrer, 1978). Adaptation has been conducted for a wind energy evaluation over the entire east coast (Garstang et al., 1978). Special runs have been made for the Chesapeake and Delaware Bay regions, extending from  $36.5^{\circ}$  N to  $39.5^{\circ}$  N;  $74.67^{\circ}$  W to  $77.5^{\circ}$  W. This area comprises the eastern half of Figure 1, with the addition northward to Delaware Bay and surroundings. The horizontal grid spacing is 10 by 10 km, with 12 vertical levels. Preliminary results (from a west-northwest prevailing wind case) show a substantial seabreeze convergence zone developing over the eastern shores of Delaware, Maryland, and Virginia and moving inland as the day progresses. Pronounced divergence develops over the Chesapeake and Delaware Bays. Other wind directions are being tested. Particular attention will be paid to possible cooling and stabilization of the marine air which might act against the cloud-promoting tendencies of the convergence zones.

Another highly flexible, subsynoptic scale model (Anthes and Warner, 1978) has shown promise of application to this area. A test case was published by Warner et al. (1978), and while this model so far does not consider soil moisture or radiational heating of the atmosphere, in contrast to the University of Virginia model, it does contain the option of a first-step parameterization of cloud processes. The latter has not yet been introduced in the coastal simulation.

b. Surface networks are being established to determine use of low-level convergence as a short-time predictor of cumulus formation and merger (Ulanski and Garstang, 1978 a,b,c).

c. Existing rain records are being studied to docu-

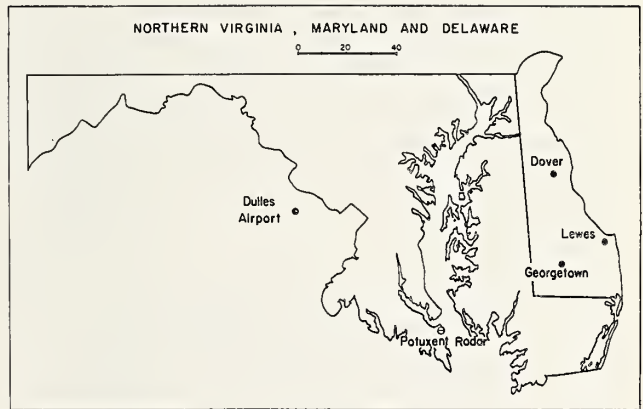


FIG. 1.—Map of the area of the study, with scale in statute miles. Dulles Airport, Virginia is the site of the soundings applied to the cloud model. The radar is located at Patuxent, Maryland. A seeding experiment involving Delaware began in June 1978, with aircraft based at Georgetown.

ment natural variability, and upgrading of gage-radar system of rain measurements. Based on these results, estimation of number of experimental cases necessary to determine a hierarchy of anticipated seeding effects at adequate significance levels. Early work is in progress at the Universities of Virginia and Delaware.

d. Empirical and theoretical predictors of rain in the target are being developed and tested which, if possible, can greatly reduce the sample size required to establish seeding effects.

e. Joint radar, aircraft and boundary-layer cloud merger studies in target are being conducted (Simpson and Woodley, 1971; Westcott, 1977).

f. A randomized area-wide experiment is being designed, executed and analyzed in the following phases:

- 1) Exploratory phase, probably requiring about 5 seasons and 100 or more cases. Minor design changes allowed during learning process.
- 2) Confirmatory phase approximately of same duration. Must have firmly specified design and analysis methods prescribed in advance. Criteria for "GO" cases must be as objective as possible, with minimum multiplicity. In other words, situations unfavorable to the concept's success should be screened out objectively in advance of an experimental day rather than by "stratifying" the data after the experiment. The seed-control comparisons must be postponed until the entire field phase is completed (Tukey et al., 1978).
- 3) Economic and environmental studies.
- 4) Transfer to operational phase.

### Motivation and Scope of This Study

This study reports results of the early steps of the first (single-cloud) phase of dynamic seedability assessment. The first step consists of using the one-dimensional cloud model, with input conditions comprising the two daily atmospheric soundings made routinely (by the NOAA National Weather Service)



at Sterling, Virginia (Dulles Airport). The sounding location is  $38.95^{\circ}$  N,  $77.45^{\circ}$  W. It was selected as the nearest radiosonde station to Delaware (Figure 1). It is about 160 km (roughly 100 statute miles) from Dover in central Delaware and Georgetown in southern Delaware. Sterling also has the advantage of being central in the inland mid-Atlantic region where additional water resources are also often needed.

Since prevailing summer winds are southwesterly, air mass characteristics should be similar between Dulles and Delaware. Some differences in the soundings at any particular time should, however, be expected. There will also be systematic differences, due to the coastal seabreeze, which will be under investigation. It remains to be seen whether the convergence effect overbalances a possible cooling and stabilization arising from invading marine air at low levels. In Florida, the seabreeze convergence zones were found to be the preferred locations for suitable cumulus clouds (Pielke and Cotton, 1978).

The Dulles sounding times are the worldwide standard of 0000 GMT and 1200 GMT which is 7 p.m. EST or 8 p.m. EDT and 7 and 8 a.m., respectively. These times have the advantage that the inland sounding is likely to be most representative of Delaware air structure, owing to the minima in land/sea-breeze effects at this time. However, Florida experience suggests that in a sea-breeze affected area, seedable cloud conditions are optimum in the afternoon hours, partly because of the added moisture mentioned above and partly because of sea-breeze convergence zones instigating cumulus growth and merger (Pielke, 1974; Simpson et al., 1977). It would be highly desirable to run similar cloud model calculations on a series of soundings made in Delaware in mid-afternoon.

While this study was specifically motivated and supported by Delaware concerns regarding rain augmentation feasibility, it is probable that these results are qualitatively applicable on a statistical basis to the middle Atlantic states roughly from New Jersey to southern Virginia. That is to say, while at a given time the sounding and hence seedability may differ vastly between parts of this area, roughly the same air mass distribution may be expected over a series of five or so summer seasons. The only anticipated major differences may be that the regions within 80 to 160 km or so from the coast may show more or less favorable seeding opportunities because of increased moisture and seabreeze convergence, perhaps compensated by cool, stable, marine air, while hilly or mountainous areas may be more favorable due to forced lifting and elevated heat sources (Mahrer and Pielke, 1975).

The second step of the first phase comprises a cloud population study using radar, satellite, and rainfall data. Although this study is still in progress, important early results are described following the discussion of the seedability assessment by the cloud model.

### Results and Analyses in First Phase

*Cloud model results*—Sounding data (pressure, temperature, and relative humidity) from Dulles air-

port over the period 1972 through 1976, May through August, was utilized in this study. Both the 0000 GMT and the 1200 GMT soundings were used. This resulted in a total of 1225 cases considered (5 soundings were missing).

To each of these soundings was applied a one-dimensional cumulus model (Simpson and Wiggert, 1969, 1971) which predicts cumulus seedability. The model estimates cloud-top height and the liquid water content of the cloud under hypothesized conditions of seeding and not seeding; the seedability is the difference between these two heights (in km). The model uses Berry's (1968) method to estimate the cloud-to-rain droplet conversion. This method allows the specification of the cloud base droplet concentration ( $N_b$ ) and the relative dispersion of the droplets ( $D_b$ ); the values for  $N_b$  and  $D_b$  used with this data were  $2000\text{ cm}^{-3}$  and 0.15, respectively, the values generally used for clouds over land. The model estimates cloud base by calculating a convective condensation level (CCL) for the sounding; this level is then used as the cloud base. The CCL is calculated by assuming mixing in the lowest 1000 m of the sounding; the average mixing ratio for this mixed layer is used to find the level on the sounding where the average mixing ratio is equal to the saturation mixing ratio, and the level found is the CCL.

The cloud model is one-dimensional because only height variations in cloud properties are considered. This model has been found satisfactory for experimental screening, but more advanced multi-dimensional models are required, for example, to predict precipitation amounts and the impacts of clouds upon their surroundings. For a discussion of the several classes of cloud models, see a review article by Simpson (1976).

The model calculates seedabilities for clouds of varying assumed radii. In this case, radii of 500, 750, 1000, 1250, 1500, 2000, 2500, and 3000 meters were used with each sounding. The maximum seedability ( $S_{\max}$ ), then, is the maximum seedability calculated for a sounding among the eight radii.

Histograms of the values of  $S_{\max}$  are shown in the following figures. Before these histograms were made, soundings with cloud bases higher than 3500 m were excluded. A total of 145 soundings was excluded for this reason, the largest number of these being May soundings.

Figure 2 shows the histogram of  $S_{\max}$  for all of the soundings (1200 and 0000 GMT) and for the 1200 GMT soundings alone. Of these, 37.13 percent of the soundings had maximum seedabilities of zero, as did slightly more of the 1200 GMT soundings alone. In general, there is not much apparent difference between the results for both times together and those for the 1200 GMT soundings alone. The mode, when the zero seedabilities are excluded, is a seedability of 2.5 to 3 km.

Figure 3 is a comparison of the Dulles predicted seedabilities with those for Miami (Wiggert and Holle, 1977). Certainly the Dulles distribution is not nearly as positive concerning seeding potential as is the Miami distribution. The Miami soundings had very few zero maximum seedabilities, and the mode is one kilometer higher than it is for Dulles, at 3.5 to 4

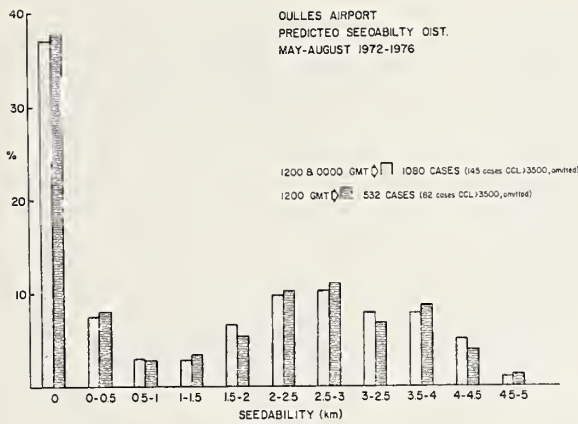


FIG. 2—Histogram of predicted seedability distribution, May-August, 1972-1976.

km. There are many more cases for Miami in the far tail with about eight percent of the maximum seedabilities greater than five km.

Comparison of the Dulles results with those for Illinois (Wiggert and Holle, 1977), however, provides a more positive result (Figure 4). While Dulles had more zero maximum seedabilities than Illinois, it also had more cases in the 2- to 4-km maximum seedability range. While the mode for Illinois (excluding zeroes) is 1.5 to 2 km, the mode for Dulles is 2.5 to 3. Although Illinois has more cases in the tail (maximum seedabilities of 4.5 to 5 kilometers and greater than 5 kilometers), these are a small percentage, less than 5 percent each.

After these comparisons were made, the model results for Dulles were stratified by month, year, and precipitation amount to determine any seedability differences caused by these factors. Figure 5 shows the histograms for the years 1972 to 1976. There does not appear to be much difference in the years except that the seedability with maximum frequency for 1975 was 2 to 2.5 km. Also, 1975 had the fewest zero maximum seedabilities of all the years.

Figure 6 shows histograms for the May, June, July, and August model results. One of the major facts obvious from this figure is that the seedabilities for May and June are generally lower than those for July

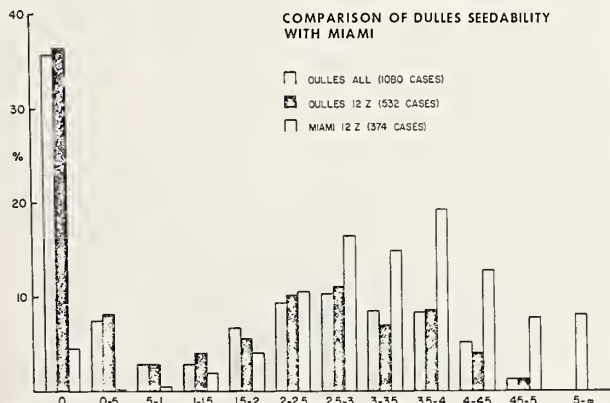


FIG. 3—Histogram comparing Dulles seedability with that of Miami, Florida.

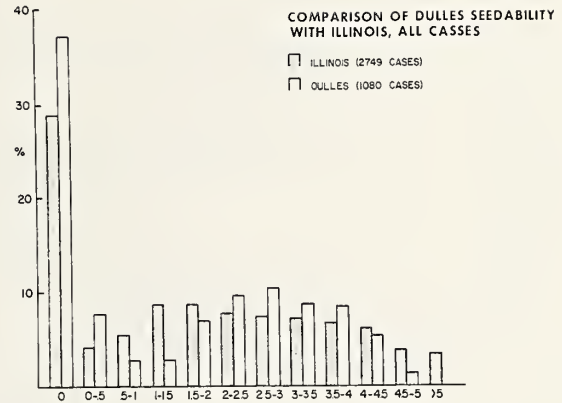


FIG. 4—Histogram comparing Dulles seedability with that of central Illinois.

and August. May has the most zero maximum seedabilities (44.9%) of the four months, followed closely by June (41.3%). July and August have 31.1 and 32.4 percent zero maximum seedabilities respectively. Sixteen percent of the August soundings have maximum seedabilities of 2.5 to 3 km compared to less than 10 percent for the other months; this is the highest non-zero  $S_{max}$  frequency.

The months were stratified into wet, medium, and dry precipitation categories based on the data shown in Table 1. The rain data shown are from Dulles Airport; however, several surrounding stations were examined to ensure that the categorization did not depend on a local anomaly. The month with the highest precipitation was June of 1972 with 18.19 in. This is much higher than the precipitation recorded for any of the other months considered here; the second highest precipitation was 7.08 in. in July of 1975. The range of precipitation for wet months was 5.38 to 18.19 in.; for middle months, 3.13 to 4.99 in.; and for dry months, 1.53 to 2.99 in.

The histograms in Figure 7 show the frequencies of values of  $S_{max}$  for the three categories of precipitation amount. The histograms are quite similar to the histogram for the entire sample, and there are not many noticeable differences between the histograms for the three precipitation categories. The dry month cate-

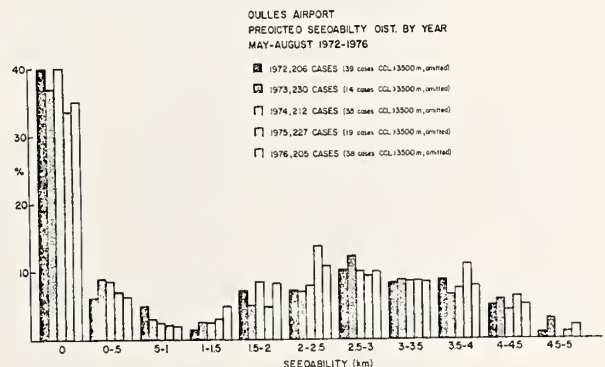


FIG. 5—Histogram showing variation of Dulles seedability by year.



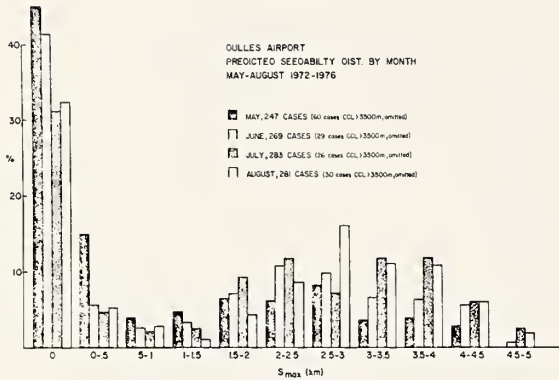


FIG. 6—Histogram showing variation of Dulles seedability by month.

gory has the fewest zero maximum seedabilities (32.4%) while the middle group has the most (40.5%). For the wet months the mode occurs with  $S_{max}$  from 2 to 2.5 km; for the middle and dry months, the mode is at 2.5 to 3 km.

This result suggests that the heavy rainfalls were produced in one or two disturbances concentrated in a few days rather than spread over a whole month, a characteristic of rainfall in most localities. Studies underway are beginning to confirm this assessment. This makes classification of total rain into disturbed and undisturbed an essential next step in the research, concomitant with efforts to determine the effectiveness of seeding under disturbed conditions, if these should contribute above half the summer rainfall. Figure 8 shows little difference in seedability between morning and evening.

To summarize the results shown in the histograms, the following points can be made:

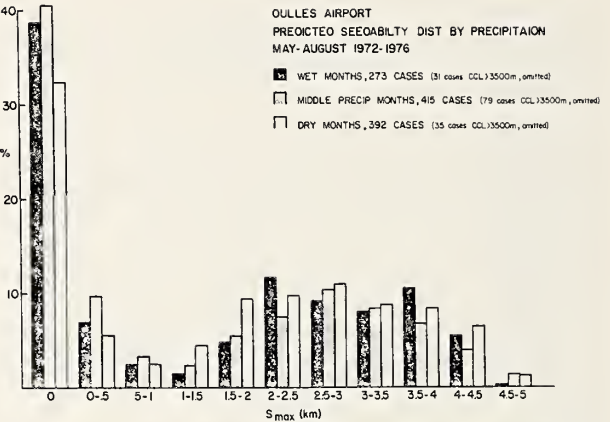


FIG. 7—Histogram showing variation of Dulles seedability by amount of monthly rainfall.

1. The predicted seedabilities indicate that northern Virginia and Delaware have a potential for seeding equal to or greater than that in Illinois. Although these seedabilities do not compare well with those for Miami, the results are still encouraging in that a good percentage of the days have nonzero maximum seedabilities.
2. No difference in seedabilities was found among the five years of this study, nor between morning and evening.
3. May and June appear to have less potential for producing high seedabilities than do July and August.
4. There is little difference in seedabilities between the wet, middle, and dry months, probably due to rain concentration in disturbances.

These results encourage further investigation into the possibility of rainfall enhancement through dynamic seeding in Northern Virginia and Delaware. Cloud population and disturbance distribution studies are next required.

*Early results of cloud population studies by radar—* Fortunately, a NOAA (National Oceanic and Atmo-

TABLE 1  
Mean monthly rainfalls at Dulles Airport  
categorized by amount

		Total Precipitation	
		(cm)	(in.)
Wet Months	June 1972	46.20	18.19
	June 1975	17.98	7.08
	July 1975	15.88	6.25
	June 1974	13.74	5.41
	August 1975	13.67	5.38
Middle Months	July 1973	12.65	4.98
	August 1974	12.29	4.84
	May 1972	12.09	4.76
	May 1976	10.62	4.18
	May 1973	10.08	3.97
	May 1974	9.60	3.78
	August 1973	8.08	3.18
	August 1976	7.95	3.13
Dry Months	May 1975	7.59	2.99
	June 1976	7.32	2.88
	July 1974	6.83	2.69
	July 1976	5.92	2.33
	August 1972	5.31	2.09
	June 1973	4.85	1.91
	July 1972	3.89	1.53

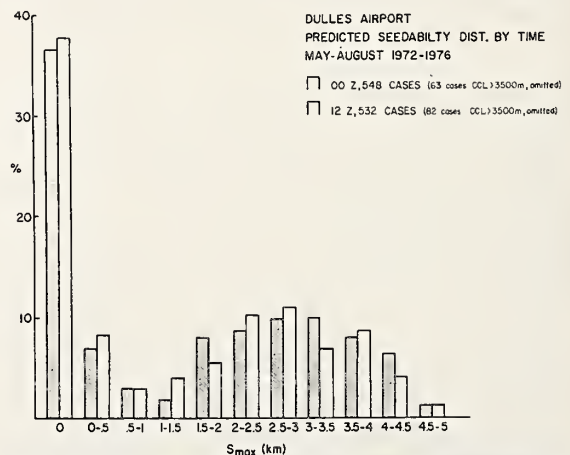


FIG. 8—Histogram showing variation of Dulles seedability between 1200 GCT (0700 EST), in white, and 0000 GCT (1900 EST), shaded.

spheric Administration) National Weather Service WSR-57 10-cm weather radar has been located since 1971 at Patuxent, Maryland (38.28° N; 76.40° W). As seen in Figure 1, this radar is about 125 km (about 78 statute miles) southeast of Dulles Airport. The entire state of Delaware is within the range of the radar, which is above 460 km for echo detection, although quantitative estimates of reflectivity and rainfall are only feasible to about 170 km. The characteristics of these radars are described by Wilson (1964) and Kessler and Wilson (1971). The digital capability of this radar has not been utilized in this report, although it will be in the experiment to be described below.

The radar data utilized so far are the coded hourly observations and the films of the scope, taken at five-minute intervals. The desired objective would be to determine how many soundings with calculated seedability were in fact accompanied by seedable cloud conditions either within view of the radar or within a specified subtarget. Cloud conditions suitable for dynamic seeding have been specified (Holle, 1974; Simpson et al., 1977). Firstly, cloud tops must be cooled below about  $-5^{\circ}\text{C}$  for silver iodide to be an effective ice nucleant. In summer, this means tops above about 5.5 km. A radar echo on the WSR-57 radar implies precipitation-sized droplets within the cloud, which usually requires tops above roughly 5 km. The height for echo formation varies, however, and clouds may occasionally attain these levels without producing 10-cm echoes. Moreover, undercooled tops are only one of several necessary conditions for dynamic seeding, which include growing towers, relative scarcity of natural ice, etc. Thus these radar data alone cannot specify suitable cloud conditions. However, periods with no radar echoes at all can almost surely be eliminated as unsuitable; hence this first step was taken. All soundings with nonzero seedability were examined and were flagged when no echoes were found on the radar from three hours before until three hours after sounding time. Results are given in Tables 2 and 3. Table 2(a) shows the flagged cases by year. Variability seems slight between years, as does that of the percent of seedable

TABLE 2

*Seedable cases left after elimination of soundings with no radar echoes for  $\pm 3$  hours*

a. Total and Yearly Breakdown							
	<i>All Years</i>	<i>1972</i>	<i>1973</i>	<i>1974</i>	<i>1975</i>	<i>1976</i>	
$S = 0$	401	82	85	85	77	72	
$S > 0$	679	124	145	127	150	133	
$S > 0$ /no echoes (flagged)	157	26	30	29	36	36	
$S > 0$ with echoes	522	98	115	98	114	97	
% loss $S > 0$	23	21	21	23	24	27	

b. Breakdown by Months and Monthly Rainfalls							
	<i>May</i>	<i>June</i>	<i>July</i>	<i>Aug.</i>	<i>Wet</i>	<i>Middle</i>	<i>Dry</i>
$S = 0$	111	111	88	91	106	168	127
$S > 0$	136	158	195	190	167	247	265
$S > 0$ /no echoes (flagged)	41	31	40	45	38	57	62
$S > 0$ with echoes	95	127	155	145	129	190	203
% loss $S > 0$	30	20	21	24	23	23	23

TABLE 3

*Summary of seedability cases in relation to radar echoes*

	<i>Number</i>
A. Total soundings available (May–Aug. 1972–1976)	1225
B. Cases too high cloud base	145
C. Number left	1080
D. Cases Zero Seedability	401
E. Number left	679
F. Cases with seedability but no echoes $\pm 3$ hr	157
G. Cases left, with seedability and echoes	522
H. Percent of total comprised by G/A $\times 100$	43

cases “lost.” However, the economics of a seeding program could be sensitive to modest variations in the number of suitable cases in a season.

Table 2(b) shows little variability in the number of flagged cases by month, but a substantial increase in remaining cases between May and July, owing to many more seedable situations in summer. Again, there is no difference between the wetness of a month (in terms of monthly rainfall) and the percentage loss of seedable cases indicated by absence of radar echoes. Table 3 shows that 43 percent of the total soundings studied had both seedability and radar echoes within  $\pm 3$  hours of sounding time somewhere on the radar screen.

This figure is probably an overestimate for good seedable cloud conditions. The overestimate increases as the subtarget is reduced relative to the entire range seen by the radar.

These results may be compared with the fact that about 26 daylight periods suitable for experimentation were found in a 96-day period in the summer of 1978 in a subtarget of 8450 km<sup>2</sup>, comprising the state of Delaware and small upwind buffer zones. This area is about 29 percent of the area quantitatively scanned by the radar, although it is only 1 percent of the area encompassed by the outer limits of view, at which only very tall clouds are seen. Thus 27 percent of the days in this area presented clouds deemed suitable for dynamic seeding, when a strict area-weighted fraction of the results in Table 3 would suggest less than half this percentage if 1978 had a summer typical of those from 1972 to 1976. Most of the suitable days were believed to have occurred in conditions ahead of a front.<sup>2</sup> The hypothesis that the seabreeze provides convergence favoring convection in the Delaware coastal area will also be pursued by both modeling and observational studies in the continuation of this research.

### Naturally Rainy or “Disturbed” Days

In south Florida, there was some evidence that dynamic seeding was less effective in increasing rainfall on naturally rainy days when a large-scale weather disturbance was dominating the air motions (Simpson and Woodley, 1971). A “disturbed” day was defined for south Florida as one on which more than 13 percent of the WSR-57 radar scope within a radius of 185 km was covered by precipitation echoes

<sup>2</sup> Information concerning the 1978 program was obtained by personal communication from Dr. Larry G. Davis, President of the contracting firm conducting the operation.



at 1400 hours local time. About half the rain in south Florida falls under disturbed conditions as defined in this manner.

This finding raises several vital questions for any proposed dynamic seeding program in the mid-Atlantic area, the primary one concerning the efficacy of dynamic seeding under naturally rainy conditions. This question can only be answered by experimentation.

We take a first step by attempting to define disturbed/naturally rainy conditions for May to August of 1975 and 1976 when half-hourly geosynchronous satellite photographs were available for the area, as well as hourly and daily rainfalls at 8 stations distributed around Dulles within a radius of about 185 km. With relatively little trial and error, a disturbed sounding period was required to meet the following criteria:

- 1) A recognizable disturbance with heavy cloud cover on the satellite photograph dominating the region;
- 2) Thirty percent or more areal radar echo coverage within 185 km of the Patuxent radar at the sounding time; and
- 3) Measurable rainfall at 4 or more of the selected stations within the 24-hr period containing the sounding.

The reason that a much larger echo coverage is required to accompany widespread rainfall in the mid-Atlantic region relative to Florida is that, in

south Florida, a radar echo and rain on the ground are virtually always associated, which is not the case in the mid-Atlantic. Higher cloud bases, different echo-producing cloud types, and different microphysical cloud structures interact in a not yet well-documented combination.

Table 4 summarizes the disturbed soundings for 1975 and 1976 using the above definition. It is noteworthy that 21 percent of the seasonal rain fell in 24-hour periods containing a disturbed sounding time. Month-by-month, the range was 0 to 51 percent of the monthly rainfall in the 24-hour periods containing a "disturbed" sounding period.

The most important question raised by this portion of the study concerns the effectiveness of dynamic seeding under disturbed conditions. While 8 of the 15 disturbed soundings, or 53 percent in 1975 and 1976, had zero calculated seedabilities, the remaining 7, or 47 percent, had substantial seedability predicted by the model. These cases could mean either a small further loss to the seedable cases with clouds reported in Table 3, or they could mean a substantial opportunity to enhance rainfall. In the Israel (Gagin and Neumann, 1974) and the Santa Barbara Projects (Elliott et al., 1971) seeding apparently becomes more effective with increasing disturbance. A plausible hypothesis for the difference is that the Florida diminution in seeding effectiveness is caused mainly by reduction in surface heating produced by the widespread layer clouds associated with a disturbance, while in Israel and Santa Barbara the convergence which forces cloud growth is caused by the disturbances themselves. In the mid-Atlantic states in summer the relative roles of cloud-forcing mechanisms are not yet known.

TABLE 4  
Rainfall under disturbed conditions in May–August 1975 and 1976  
Dulles Airport, Virginia

Summary for 1975					
Month	Total rain		Disturbed rain		
	(cm)	(in.)	(cm)	(in.)	
May	7.59	2.99	2.08	0.82	
June	17.98	7.08	2.95	1.16	
July	15.88	6.25	8.13	3.20	
August	13.67	5.38	0	0	
Subtotal	55.12	21.70	13.16	5.18	24% seasonal rain disturbed 6 disturbed sounding periods S = 0 4 disturbed sounding periods S > 0
Summary for 1976					
May	10.62	4.18	3.66	1.44	
June	7.32	2.88	0	0	
July	5.92	2.33	1.57	0.62	
August	7.95	3.13	0	0	
Subtotal	31.81	12.52	5.23	2.06	16% seasonal rain disturbed 2 disturbed sounding periods S = 0 3 disturbed sounding periods S > 0
Overall	86.93	34.73	18.49	7.24	21% seasonal rain disturbed 8 disturbed sounding periods S = 0 7 disturbed sounding periods S > 0

### The 1978 Summer Experiment in Delaware

In the summer of 1978, the Delaware agriculturists convinced the State Legislature to fund a modest dynamic seeding program run by a private contractor under the supervision of the State Department of Agriculture. It will be evaluated by the Agricultural Experiment Station of the University of Delaware.

A single aircraft equipped with silver iodide pyrotechnic flares operated from Georgetown (Figure 1) by radar guidance. A combination of operational and randomized experimental seeding was conducted, with the seed treatment allotted on a two to one basis during the randomized portion. Dummy flares were used on the random control days. Nine random cases were obtained which had not been immediately preceded by operational seeding, and three random cases were discarded for that reason. An estimated 14 additional suitable days were not utilized owing to either air traffic problems or "stand down" criteria (e.g. more than adequate crop moisture). It is hoped that the existing data will be used to estimate the number of cases required to detect several levels of seeding effects at adequate significance levels.

### Conclusions and Further Outlook

While preliminary indications have been shown here to be favorable for rain augmentation by dy-

dynamic cloud seeding in the mid-Atlantic states, much more modeling research combined with measurements must be undertaken before a full-scale area experiment is advisable. More must be known about the cloud-forcing mechanisms as well as about the dynamics, microphysics, and distributions of the clouds.

The necessary research steps have been outlined in this paper; they can proceed in parallel with controlled experimentation, particularly if that experimentation is conducted first on single clouds to rapidly build up a sizable, well-documented sample under varying weather conditions, over about two seasons.

If the decision must be made to continue immediately with area-wide experimentation, this can only be done soundly by incorporating an adequate research infrastructure, including joint modeling and cloud and mesoscale measurements as has been done in Florida and in the High Plains Experiment (HIPLEX) of the U.S. Bureau of Reclamation (Silverman, 1977). Without these vital components, an inapplicable hypothesis may be tested inadequately, leading at best to waste and confusion and at worst to negative results, i.e. rainfall decreases, which have been shown to have been the probable outcome of at least one earlier seeding effort (Braham, 1978).

In conclusion, beneficial modification of cumulus rain appears promising in the mid-Atlantic, in that it has passed the first relatively simple tests described here. The difficult and expensive tests are still to come. That the potential benefit from conducting these tests makes the effort worth undertaking has been cogently recommended by a national board of experts (Cleveland et al., 1978). This Board has considered the nation's needs, the economics, environmental impacts, and the legal and societal ramifications in their recommendation.

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### Literature Cited

- Anthes, R. A. and Warner, T. T. (1978): Development of Hydrodynamic Models Suitable for Air Pollution and Other Meteorological Studies. *Mon. Wea. Rev.* **106**, 1045-1078.
- Berry, E. X. (1968): Modification of the Warm Rain Process. *Proc. First Nat'l Conf. on Weather Modification*, Albany, N.Y., AMS, pp. 81-85.
- Braham, R. R. (1978): Field Experimentation in Weather Modification. *J. Am. Statistical Assoc.*, in press.
- Cleveland, H. and 17-member board (1978): *The Management of Weather Resources*, Vol. 1, 229 pp., Dept. of Commerce, Washington, D.C.
- Elliott, R. D., St. Amand, P. and Thompson, J. R. (1971): Santa Barbara Pyrotechnic Cloud Seeding Test Results, 1967-1970. *J. Appl. Meteor.* **10**, 785-795.
- Gagin, A. and Neumann, J. (1974): Rain Stimulation and Cloud Physics in Israel. In *Weather and Climate Modification* (W. N. Hess, ed.), pp. 454-494, Wiley, New York.
- Garstang, M.; Aspliden, C. I.; Athey, G.; Gusdorf, J.; Nnaji, S.; Pielke, R. and Snow, J. W. (1978): *Coastal Zone Wind Energy Studies*, Washington, D.C., in press.
- Hallett, J.; Sax, R. I.; Lamb, D. and Murty, D. S. Ramachandra (1978): Aircraft Measurements of Ice in Florida Cumuli. *Quart. J. Roy. Met. Soc.* **104**, 631-652.
- Holle, R. (1974): Populations of Parameters Related to Dynamic Cumulus Seeding over Florida. *J. Appl. Meteor.* **13**, 364-373.
- Illinois State Water Survey; Agricultural Experiment Station, University of Illinois; Agricultural Experiment Station, Michigan State University; Ohio Agricultural Research and Development Center; and Agricultural Experiment, Purdue University (1978): Overview and Plan of Precipitation Augmentation for Crops Experiment. Illinois State Water Survey.
- Kessler, E. and Wilson, J. W. (1971): Radar in an Automated National Weather System. *Bull. Amer. Meteor. Soc.* **52**, 1062-1070.
- Mahrer, Y., and Pielke, R. A. (1975): A Numerical Study of the Air Flow over Mountains Using the Two-Dimensional Version of the University of Virginia Mesoscale Model. *J. Atmos. Sci.* **32**, 2144-2155.
- Malkus, J., and Simpson, R. H. (1964): Modification Experiments on Tropical Cumulus Clouds. *Science* **145**, 541-548.
- Pielke, R. A. (1974): A Three-Dimensional Model of the Sea Breezes over South Florida. *Mon. Wea. Rev.* **102**, 115-139.
- Pielke, R. A. and Cotton, W. R. (1978): The Evolutionary Characteristics of Sea and Lake Breeze Generated Convective-Mesoscale Systems over South Florida. Submitted to *Mon. Wea. Rev.*
- Pielke, R. A., and Mahrer, Y. (1978): Verification Analysis of the University of Virginia Three-Dimensional Mesoscale Model Prediction over South Florida for July 1, 1973. *Mon. Wea. Rev.* **106**, in press.
- Silverman, B. A. (1977): HIPLEX—An Overview. Preprints, Sixth Conf. on Inadvertent and Planned Weather Modification. *Amer. Meteor. Soc.*, Champaign-Urbana, pp. 211-314.
- Simpson, J. (1976): Precipitation Augmentation from Cumulus Clouds and Systems: Scientific and Technological Foundations, 1975. *Advances in Geophys.*, **19**, 1-72.
- Simpson, J. (1978): What Weather Modification Needs. *J. Appl. Meteor.* **17**, 858-866.
- Simpson, J.; Biondini, R.; Sax, R. and Woodley, W. L. (1977): On Criteria for Area-Wide Dynamic Cumulus Seeding Experiments. Preprints, Sixth Conf. on Inadvertent and Planned Weather Modification, Champaign, *Amer. Meteor. Soc.*, Oct. 10-13, 1977, pp. 226-229.
- Simpson, J., Brier, G. W. and Simpson, R. H. (1976): Stormfury



- Cumulus Seeding Experiments (1965): Statistical Analysis and Main Results. *J. Atmos. Sci.* **24**, 508-521.
- Simpson, J., and Dennis, A. (1974): Cumulus Clouds and Their Modification. In *Weather and Climate Modification* (W. N. Hess, ed.), pp. 229-281, Wiley, New York.
- Simpson, J., Simpson, R. H., Andrews, D. A. and Eaton (1965): Experimental Cumulus Dynamics. *Rev. Geophys.* **3**, 387-431.
- Simpson, J. and Wiggert, V. (1969): Models of Precipitating Cumulus Towers. *Mon. Wea. Rev.* **97**, 471-489.
- Simpson, J. and Wiggert, V. (1971): 1968 Florida Cumulus Seeding Experiment: Numerical Model Results. *Mon. Wea. Rev.*, **99**, 87-118.
- Simpson, J., and Woodley, W. L. (1971): Seeding Cumulus in Florida: New 1970 Results, *Science*, **172**, 117-126.
- Simpson, J. W., Woodley, W. L., Friedman, H. A., Slusher, T. W., Scheffee, R. S. and Steele, R. L. (1970): An Airborne Pyrotechnic Cloud Seeding System and Its Use. *J. Appl. Meteorol.* **9**, 109-122.
- Simpson, J.; Woodley, W. L. and Miller, A. (1971): Precipitation Results of Two Randomized Pyrotechnic Cumulus Seeding Experiments. *J. Appl. Meteor.* **10**, 526-544.
- Simpson, J., Woodley, W. L. and White, R. M. (1972): Joint Federal-State Cumulus Seeding Program for Mitigation of 1971 South Florida Drought. *Bull. Amer. Meteor. Soc.* **53**, 334-344.
- Tukey, J. W., Brillinger, D. R. and Jones, L. V. (1978): *The Management of Weather Resources*, Vol. II, 94 pp., Dept. of Commerce, Washington, D.C.
- Ulanski, S. L. and Garstang, M. (1978a): The Role of Surface Divergence and Vorticity in the Life Cycle of Convective Rainfall. Part I: Observation and Analysis. *J. Atmos. Sci.* **35**, 1047-1062.
- Ulanski, S. L., and Garstang, M. (1978b): The Role of Surface Divergence and Vorticity in the Life Cycle of Convective Rainfall, Part II: Descriptive Model. *J. Atmos. Sci.*, **35**, 1063-1069.
- Ulanski, S. L., and Garstang, M. (1978c): The Structure of Convective Rainfall. *J. Water Resources*, in press.
- Warner, T. T., Anthes, R. A. and McNab, A. L. (1978): Numerical Simulations with a Three-Dimensional Mesoscale Model. *Mon. Wea. Rev.* **106**, 1079-1099.
- Westcott, N. (1977): Radar Characterization of South Florida Convective Rainfall. Preprint Vol., Sixth Conf. on Inadvertent and Planned Weather Modification, Amer. Meteor. Soc., Champaign-Urbana, pp. 190-193.
- Wiggert, V., and Holle, R. L. (1977): Supercooled Cloud Seeding Potential in Illinois from Soundings and Radar. Preprint Vol., Sixth Conf. on Inadvertent and Planned Weather Modification, Amer. Meteor. Soc., Champaign-Urbana, pp. 270-273.
- Wilson, J. W. (1964): Evaluation of Precipitation Measurements with the WSR-57 Weather Radar. *J. Appl. Meteor.* **3**, 164-174.
- Woodley, W. L., Jordan, J. A., Simpson, J., Biondini, R. and Flueck, J. (1978): NOAA's Florida Area Cumulus Experiment (FACE 1): 1970-1976. Submitted for publication in *J. Appl. Meteor.*
- Woodley, W. L., Jordan, J. A., Simpson, J., Biondini, R., and Flueck, J. (1978a): Final Rainfall Results of the Florida Area Cumulus Experiment. NOAA Tech. Report, in progress.

# Potential of Detecting Urban and Oceanic Thermal Anomalies from Space\*

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**Abstract**—Origin and properties of thermal anomalies caused by oceanic eddies of all sizes, natural and man-made islands, and cities are described. Possible influences of these thermal anomalies on regional environment are discussed. The chronological advance in space technology to detect these anomalies is traced and illustrated. Potential applications of this technology to urban design are indicated.

## Introduction

Accurate measurements of spatial contrasts in temperature from space have the potential of providing us with a means for improved urban design and selection of potential sites for offshore facilities for work and pleasure. Concerns over growing population, high density urbanization, industrial expansion, increasing commerce and transportation, critically rising need to develop energy resources, and protection of life and property against deteriorating quality of air have led in recent years to considerations of constructing offshore airports, power plants, oil storage and tanker anchorage facilities, deep water seaports and facilities for other industrial and recreational facilities on man-made islands built with waste-disposal landfills. Deterrents to such apparently off-beat concepts have been the possible adverse influences of these facilities on the marine environment and life.

\* An updated and selectively combined version of two papers titled (a) atmospheric and oceanic flow problems introduced by off-shore facilities and icepacks, and (b) studies of heat islands from space. These papers were presented to the Environmental Sciences Section at the Academy's annual meetings held in 1975 and 1976. The abstracts appeared in *Va. J. Sci.* **26**, 80 (1975), and **27**, 75 (1976).



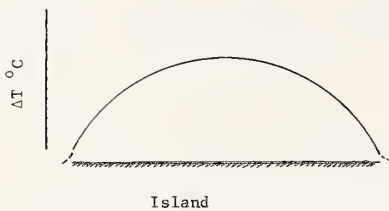


FIG. 1(a). Surface temperature profile (ideal) across a heated island.

and the related impact on the seafood industry. Very little thought has been given to the stability and life span of such facilities with cost-benefit effectiveness in perspective. Much less attention has been paid to the question of whether such facilities, particularly offshore airports, power plants and oil storage facilities, shall create hazardous environments through the *heated island effects*.

Natural islands introduce a variety of interesting mesoscale atmospheric and marine circulations, determined by an island's shape and size, its geographic location and terrain, its proximity to other land masses, stability and nature of the large scale prevailing winds, Earth's rotation, etc. Some islands are able to severely modify a region's climate by creating cloud rows, squall lines, and regions of increased thunderstorm and precipitation activities. Recent studies have shown that cities, acting as heated islands, simulate similar climatic effects and weather phenomena. Combined with human activities in urban centers, these effects are further complicated by considerations of worsening air quality and the accompanying influences on our health and physical well being.

Hot and cold patches (eddies) of water on the planetary- and meso-scales are usually found in pairs. These thermal anomalies result from some known and mostly yet unknown causes. Irrespective of their origin, oceanic eddies are excellent examples of air-sea interaction and provide a mechanism for mixing, leading to transport and storage of solar heat in water, and exerting an influence on the local climate.

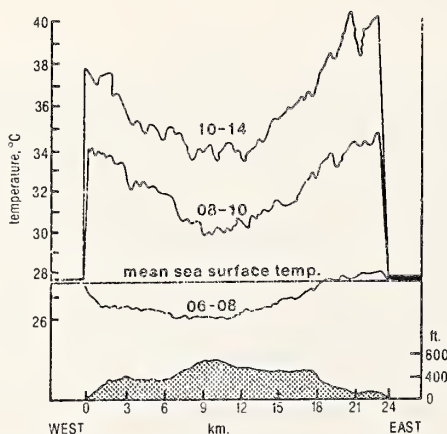


FIG. 1(b). Mean surface temperature profile across Barbados island at 6-8, 8-10 and 10-14 hours local time (after Holley, 1972 in Garstang, 1975).

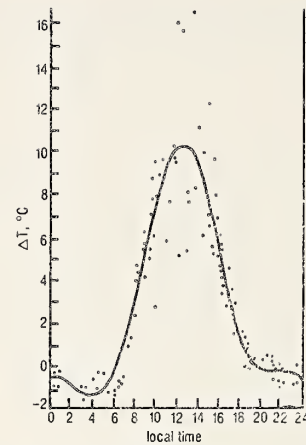


FIG. 1(c). Diurnal variation of the Barbados heat island effect (after DeSouza, 1972 in Garstang, 1975).

The past 3 decades have provided us with considerable insight into the meteorology and oceanography of islands. Urban heat islands have been studied for several decades, but, during the past 10 years, we have gained insight into some meteorological effects introduced by cities. We understand that the urban heated islands are characterized by a fine structure — a network of mini heated islands. A better understanding of these effects on the micro- and macro-scales shall find applications in urban land use, coastal zone management, and design of offshore facilities. To gain this knowledge, we need continuous and simultaneous surface measurements of large metropolitan areas. In 1975, Chopra and Trafford proposed a detailed heated island study with LANDSAT for possible land use on the Eastern Shore. Does the space technology exist to provide this information more reliably and at less cost than the conventional synoptic and ground-based methods of data collection?

To answer this question, we first examine our present knowledge of the environmental effects introduced by cities and islands acting as sources of heat. Two book length articles by Chopra (1973) and Garstang, et al. (1975) discuss these phenomena in considerable detail and include comprehensive bibliographies. Results of the project METROMEX, treating St. Louis as the model city for the study of urban environment, are described in a series of articles in the *Bulletin of the American Meteorological Society*, Vol. 55, No. 2, pages 87-121 (February, 1974). These references are suggested for gaining greater technical depth and detail, and for leads to the original literature.

Thermal contrasts caused by upwelling and eddy phenomena in the ocean are considered in the next section. This is followed by the description of examples of remote sensing of contrasts in temperature associated with the following: currents, eddies, ice-packs and upwellings in oceans; large metropolitan areas, fields for pasture and melting of snow in corn-fields over land; and such environmental effects as fronts, plumes and tropical storms. Discussion of the limitations of the current state of technology for ap-

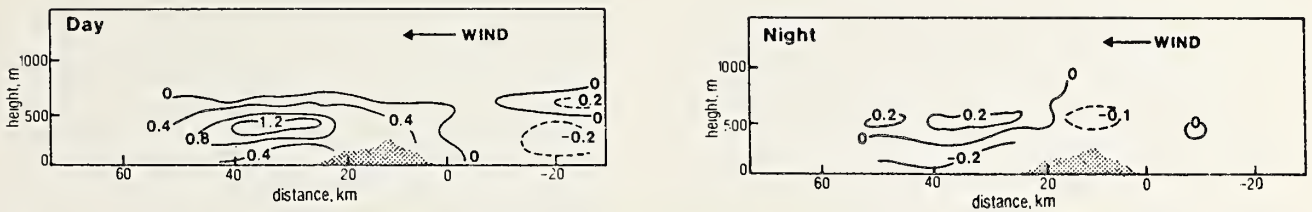


FIG. 2(a). Thermal plume associated with the Barbados island (after DeSouza, 1972 in Garstang, 1975).

plication to urban coastal design forms the concluding section.

### Natural Islands

Islands act as obstacles to the prevailing winds, as sources of heat during the day, and modify the local environment. Even observational platforms and very small islands generate microscale perturbations in wind and temperature. Most islands modify the local environment through the *heated island effect* produced by the differential heating of the adjoining land

and water masses. Solar heat absorbed by land warms only its very thin skin layer whereas the sea absorbs and stores solar energy in a larger and deeper volume via turbulent mixing caused by winds, waves, currents and evaporation. Furthermore, the thermal capacity of land is much lower than that of water. Therefore, temperature\* over land during the day can be as much as 5 times that over the adjacent water surface. Contrasts in temperature as high as 13 °C have been reported for the Grand Bahamas Island. Fig. 1 shows: (a) the ideal surface temperature profile across a heated island; (b) observed mean surface

\* Celsius scale.

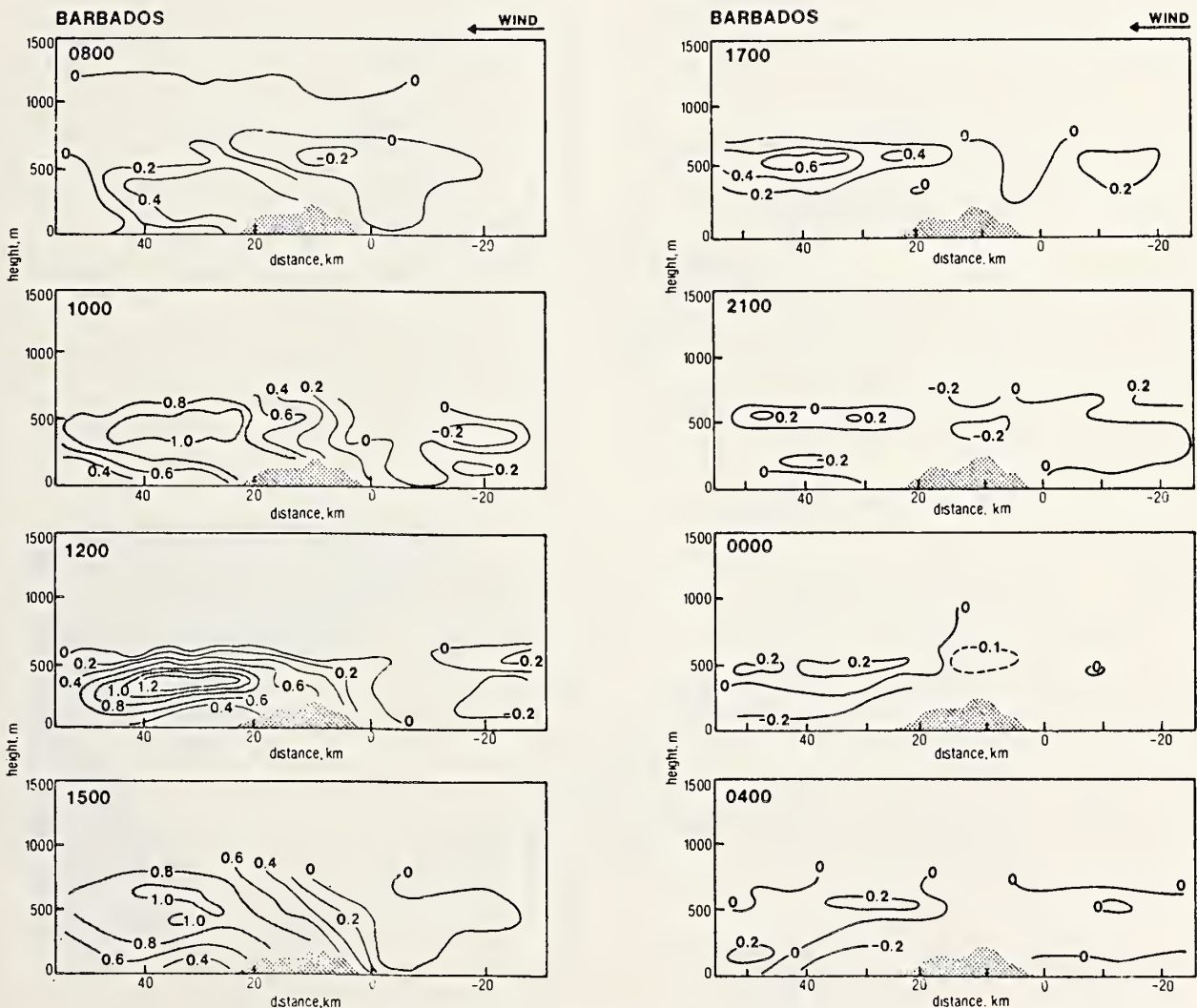


FIG. 2(b). Evolution of a thermal plume over the Barbados island (after DeSouza, 1972 in Garstang, 1975).



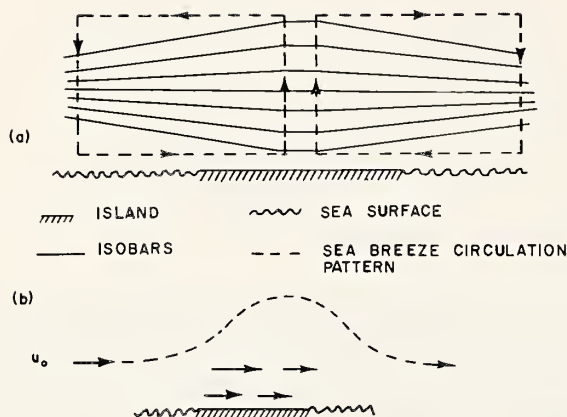


FIG. 3. Ideal sea breeze pattern over a uniformly heated island (a) in the absence of prevailing winds; (b) under the influence of strong prevailing winds. Length of arrow indicates magnitude of wind speed.

temperature profile across the Barbados at 6–8, 8–10, and 10–14 hours local time during the summers of 1968 and 1969; and (c) the diurnal variation of the island-sea surface temperature difference for the Barbados Island. Lower temperatures over the central part of the island in Fig. 1(b) are due to the altitude.

Downwind advection from a heated island can produce a thermal plume. Fig. 2(a) shows the mean daytime height of the plume at 600 m with maximum positive departures of  $1.2^\circ\text{C}$  occurring at about 400 m above and downwind of the island's west coast. No such pronounced anomalies are observed at night. Fig. 2(b) describes the evolution of the plume's diurnal changes. The plume, with positive departure in temperature exceeding  $0.6^\circ\text{C}$ , appears to start developing at about 9 a.m., acquires its maximum strength at noon, grows to its largest size in the mid-afternoon, and dissipates to a mere residual size at 600 m altitude at about 5 p.m.

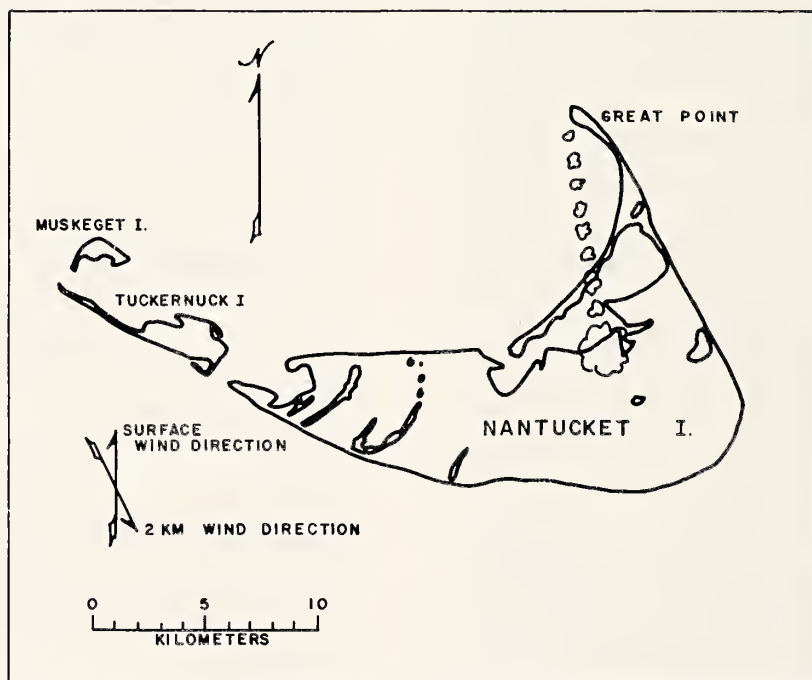


FIG. 4(a). Rows of clouds off the Nantucket Island (after Malkus and Bunker, 1952 in Chopra, 1973).

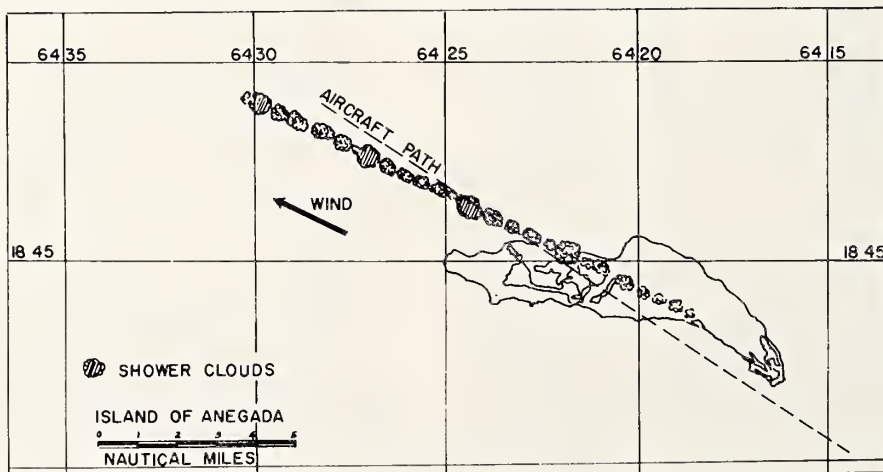


FIG. 4(b). Cloud rows formed by the Anegada Island (after Malkus, 1963 in Chopra, 1973).

Large island-sea temperature contrasts give rise to a sea breeze (Fig. 3). As the warm air rises over land during the day, cooler air from the sea flows over land. Being denser than the air over land, the colder air over the sea sinks. The reverse (land breeze) occurs at night. The direction, instants of onset and retreat, intensity and vertical depth of the sea breeze depend on such factors as the prevailing winds, stability of the local atmosphere, island's size, and its topography. Land and sea breezes are best developed where the magnitude of the island-sea thermal contrast and the diurnal variation in the mean temperature are large. This is typical in the tropics. Prevailing onshore winds and the presence of a low-level inversion layer enhance the sea breeze effect. Rising moist air tends to increase cloud cover and precipitation. The islands of Cuba and New Caledonia are classic examples of the sea breeze phenomenon.

Certain islands do not produce effects of the type just discussed. For example, the island of Niue displays no land or sea breezes, and observations from Barbados, Bermuda and some Pacific islands show evidence in which wind speeds decrease on the upwind side and increase on the downwind side of the islands as heating progresses.

Rows of cumulus clouds with periodic spacings of 1 to 1.5 km (Fig. 4(a)) and extending to great distances downwind of the Nantucket Island are frequently observed on sunny summer days. Similarly, the Island of Anageda produces showering clouds (Fig. 4(b)) which are 1.8-km-thick and arranged 5.2-km apart in a single row, 24-km long, parallel to the ambient wind direction. No rain falls on the Anageda, but it pours further downwind of the island. Heating of the island is a necessary condition for the appearance of a cloud row which grows and disappears with sun. The rainfall associated with the Grand Bahama Island is also most pronounced at and just downwind from its leeward edge.

A stable flow of air causes wind to separate on the upwind side and converge on the leeward side. This convergence is likely to produce rainfall on the lee-

ward side of an island. During lull periods when the low-level flow is generally easterly to northeasterly in the northern part of the South China Sea, bands of showers develop during the night and dissipate during the morning hours in a zone about 150-km long and about 30-km wide, extending towards the west or southwest from Hainan (Fig. 4(c)). Tall islands also produce showers in the convergence zone on the island's leeside. Heavy rainfall over the Kona coast of Hawaii results in this manner. Hence, the nature of stability of local air determines whether rain would fall on the windward or the leeward side of the island.

### Urban Heat Islands

Although urban heat islands have been studied for a long time, rapid advances in our understanding of the inadvertent weather modification introduced by cities have come from a recent extensive (five year long) study of the St. Louis area under project METROMEX (Metropolitan Meteorological Experiment). It is well known that cities are 1 to 3 C° (2 to 6 F°) warmer; have 6 to 10% lower relative humidity, but 5 to 10% more cloudiness and rainfall; more frequent occurrences of fogs and severe storms; more frequent and longer lasting thunderstorms; and lower windspeeds with less gustiness than the surrounding region. Fig. 5 illustrates these anomalies in weather for the city of St. Louis which is 3 to 5 F° warmer than the surrounding region. The city experiences a 40% increase in summer rain and 60% increase in number of storms which produce more than an inch of rain. The rainfall is heavier over and downwind from the city.

Extremes in averaged differences in temperature of 10 C° for Barbados, 11 C° for New York and Montreal, and 13 C° for Grand Bahama Island have been reported, and extreme heat island effects of 14 C° (Berlin), 16 C° (Barbados) and 20 C° (Toronto) have been observed. These urban heat anomalies are caused by complex shapes of city structures with

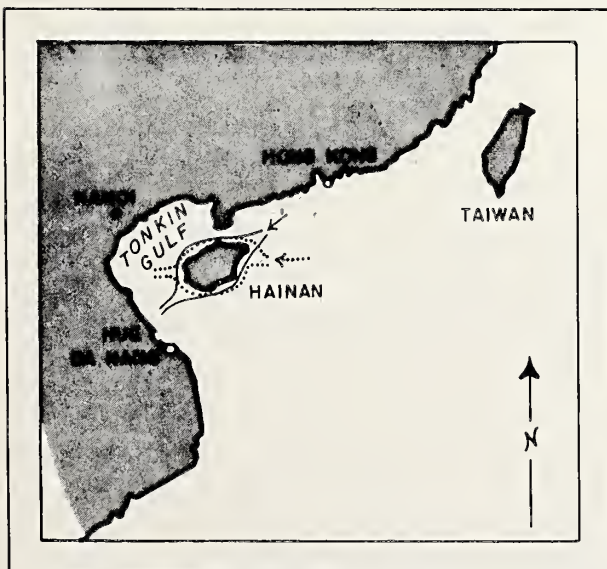


FIG. 4(c). Rain band downwind of the Hainan Island.

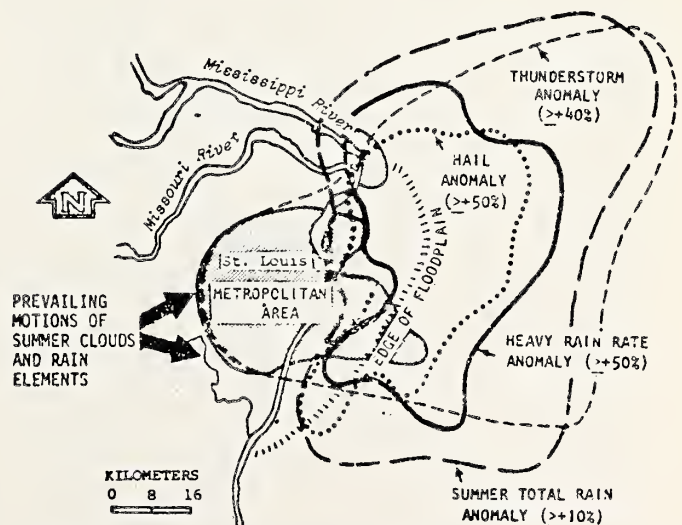


FIG. 5. Thermal and weather anomalies associated with the City of St. Louis (Project Metromex Map).



larger heat capacity, industrial, residential and automotive sources of heat and air pollutants than those found in rural areas. Large buildings force air to rise and cool, leading to the condensation of water vapor on dust particles to produce clouds and rain. Similarly, more frequent occurrence of fogs in cities and suburbs is due to the city-ward flow of colder and moister rural air encountering tiny particles in the city air.

Certain contrasts in thermal anomalies associated with islands and cities result from the nature of surface inhomogeneities and their response to solar radiation. Islands respond to solar radiation during the day and to radiative cooling during the night. Also, water has higher heat capacity and lower surface roughness compared to land. Combined with relatively homogeneous surface features of islands, these conditions cause the island-ocean contrast in temperature to exhibit a stepwise discontinuity which is more pronounced during the day than at night, and shows a distinct diurnal variation.

The conditions for urban heat islands are distinctly different. City structures have higher thermal capacity than the rural soil; the urban-rural discontinuity in surface features is seldom as sharp as in the island-ocean case; and certain heat sources related to industrial and human activities continue to operate at night. Therefore, the urban heat island may not show any diurnal variation or a stepwise spatial discontinuity in temperature. Furthermore, the urban heat island effect may be more pronounced at night. For example, the temperature of St. Louis is on the average  $5.6^{\circ}\text{C}$  ( $10^{\circ}\text{F}$ ) higher than in its surroundings at night.

With complexities introduced by non-uniform geometry and arrangements of its buildings and streets, artificial heat generation and air pollution, a city develops a fine structure within its heat island. Even a small but compact shopping center within a well-defined surrounding residential area can produce a pronounced heat island effect. This small scale but often pronounced effect is due to differential heating caused by asphalt-covered parking lots and paved streets, and greater concentration of airconditioning and heating systems, automobiles and people in the shopping center. Cooling produced by evaporation of water from plants and trees in parks, or from recreational areas within residential complexes, also contributes to the enhancement of this effect. Figs. 6(a) and (b) respectively show thermal features of the Wards Corner Shopping Center<sup>1</sup> on April 16, 1971 and Wards Corner and Southern Shopping Centers on May 6, 1971. Similar patterns were observed repeatedly on clear afternoons during the summers of 1971 and 1972.

These shopping centers are located in Norfolk, Virginia and were chosen for a number of reasons. Wards Corner is a symmetrical, small but busy shopping center, with a very sharp discontinuity between the commercial and residential areas. A major traffic intersection with heavy traffic throughout the day is located at the center of the Wards Corner, and the sea breeze is strong along one of the streets in midafternoon. The Southern Shopping Center was chosen for

its contrast in complexity and closeness to the Wards Corner. Commercial buildings are arranged in two groups on opposite sides of Tidewater Drive and are further separated by extensive parking areas. The residential area consists of one- and two-storied houses located north of Little Creek Road. Therefore, sea breeze from the north is uniform and weak. Furthermore, the Southern Shopping Center is asymmetrical, and the contrast between the commercial and residential areas is not as sharp as around Wards Corner.

The observations provided support for our expectations. The heat island effect was symmetrical and pronounced around Wards Corner. The sea breeze produced strong mixing (not shown in Fig. 6) along Granby Street, and practically wiped out the heat island effect north of Little Creek Road in the Southern Shopping area. Isolated small colder regions associated with dense greenery and/or shape of terrain were also observed during the field trips.

Certain locations in the urban and suburban areas are marked with more frequent occurrence of fogs, or with relatively excessive or deficient rainfall, or with better or poorer quality of air. These effects are related to the mini-heated islands within the urban heat island, the associated air circulations, and the nature of local terrain and its surface features. For example, light and moderate fogs occur more frequently in cities and may be attributed to combustion processes which produce particulates and water vapor. On the other hand, the dense fogs occur most frequently in the suburbs. Even the light and moderate fogs occur more frequently than expected from interpolation between rural and urban areas. This can be attributed to the advective processes. Similarly, fogs are more likely to form between two shopping centers or between a shopping center and the neighboring residential area. Two neighboring shopping centers may generate an air circulation pattern of the type shown in Fig. 7, with gaseous material picked up convectively from the shopping centers and dumped above the residential area, while the heavier particulates drift along the surface away from the shopping centers. Such circulation patterns have a bearing on the quality of air and microscale features of weather, and these should be considered in city planning.

### Sea Surface Thermal Anomalies

Sea surface thermal anomalies are found in abundance at any time of observation. Most of these are associated with the upwelling (or downwelling) phenomena introduced by offshore (or onshore) currents or eddies. Colder water from the subsurface layers is brought to the surface and removed from the region of upwelling by surface flow. Downwelling of water accompanies upwelling, the two forming a mesoscale vertical solenoidal current. Surface temperature is lower, and the density and salinity of surface water are higher in a region of upwelling than in a region of downwelling. Among these properties, spatial variation of temperature is the most pronounced feature. At the center of a *cyclonic* eddy, the surface temperature is usually  $1$  to  $2^{\circ}\text{C}$  lower than at its periphery. Surface wind shear appears to play a significant, but not well understood, role in the upwelling phenomenon.

<sup>1</sup> Presented at the 1971 Annual Meeting of the Virginia Academy of Science. Abstract appeared in *Va. J. Sci.* **22**, 91 (1971)

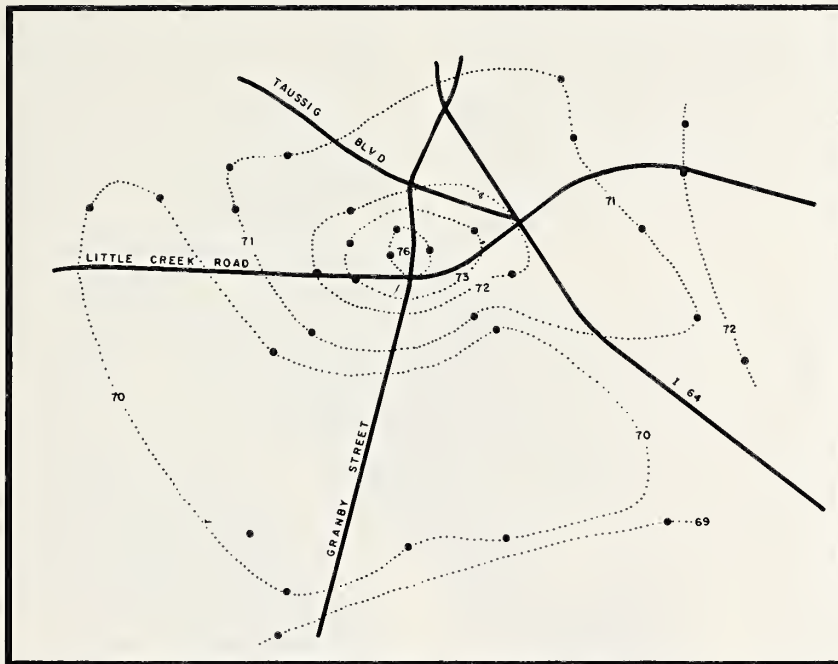


FIG. 6(a). Heat island effect of the Wards Corner Shopping Center, Norfolk, Virginia on April 16, 1971, 1500–1600 hours EDT (after Chopra and Pritchard, 1972 in Chopra, 1973).



FIG. 6(b). Heat island effect of the Wards Corner and Southern Shopping Centers in Norfolk, Virginia on May 6, 1971, 1500–1600 hours EDT (after Chopra and Pritchard, 1972 in Chopra, 1973).



FIG. 7. Air circulations introduced by two neighboring shopping centers (after Chopra, 1973).



The sea surface temperature anomaly is often used to identify regions of upwelling. This identification is of value in commercial fisheries. Upwelling and surface layer divergence cause enrichment of the surface layers by lifting more nutritious water from lower layers. This increases the productivity rate of organic matter in these regions. Greater abundance of fish off the coast of Peru and in certain equatorial regions is attributed to intense coastal and equatorial upwelling.

Sea surface thermal anomalies on the planetary scale are also known to occur. These are called hot and cold patches and appear in pairs. For example, a cold patch in the mid-Pacific accompanies a warm patch off the California coast. These anomalies are associated with global climate differences. In the case of the cited pair of patches, the eastern United States would have colder than normal winters and the western half of the country would have warmer than usual winters. The exact mechanism of generation of these anomalies is not known. It appears, however, that the heat flux in the upper layer and the depth of the mixing layer play a significant role because these two factors determine the extent of the ocean reservoir for storage of solar heat which is later drawn by the atmosphere. The North Pacific Experiment (NORPAX) is expected to shed light on the nature of the interaction between large scale ocean temperature anomalies and weather.

Offshore airports and powerplants are likely to alter the heat balance and shear in the surface layer of the marine environment. Thermal pollution caused by power plants is likely to render the air unstable as well as enhance evaporation, causing an increase in salinity and density of surface water leading to convective mixing. Icebergs and icepacks, on the other hand, introduce the reversed heat island effect, as well as convective (solenoidal) currents in the underlying water by cooling it and increasing its density.

### Thermal Anomalies Observed From Space

The feasibility of detecting and/or monitoring thermal contrasts of 10 °C extending over very large areas was first demonstrated by the scanning infrared radiometers, operating in the 8 to 12  $\mu$  wavelength range, aboard TIROS III and VII satellites. Thermal images of Earth, generated by these scanners during TIROS III Orbits 56-63 on July 16, 1961 and TIROS VII orbits 3195-3203 on January 21-22, 1964 are quite impressive as shown in Figs. 8 and 9.

Because of its large size, its being 8 to 12 °C warmer than the adjoining sea water and other unusual features, the Gulf Stream became a prime subject for earlier radiometric studies from space. The high resolution infrared radiometer (HRIR 3.5-4.1  $\mu$ ) aboard Nimbus II clearly detected the boundary of the Gulf Stream on June 2, 1966 (Fig. 10).

*Eddy Dynamics:* The Improved TIROS Operational Satellite (ITOS-1) was the first environmental satellite to provide a fine thermal structure of anomalies over land and sea. When looking straight down at Earth's surface, the scanning radiometer aboard ITOS-1 instantaneously viewed an area 7.5 km in diameter, and its infrared channel measured radiation in 10.5-12.5  $\mu$

wavelength region. Fig. 11(a) shows the nighttime direct readout infrared (DRIR) imagery obtained on October 19, 1970 (Rao et al, 1971). Because of the thermal contrast with warmer sea surface, features of the colder landmass boundary of the mid-Atlantic Bight stands out. The thermal front on the northern edge of the Gulf Stream is prominent. Portions of the Gulf Stream to the south and east of the front, however, are obscured by colder clouds. The shaded areas identify three water masses: (i) Gulf Stream, 22 °C; (ii) slope water, 18-22 °C; and (iii) shelf water, 18 °C. Rao et al. claim reliability of the infrared data within 2 °C of the available surface data. From an analysis of digitized infrared data taken about 0900 GMT (0300 local time) on the same day, Rao (1972) inferred urban heat island effects associated with New York, Philadelphia, Baltimore and Washington, D.C. (Fig. 11(b)). The heavily shaded area represents a region of temperature from 6 to 8 °C, and the vertically hatched area represents a region with temperature from 2 to 5 °C. Fig. 11(c) represents the infrared image, taken at 0900 GMT, on April 12, 1971. Eddies along the Gulf Stream boundary are readily observable.

Infrared images of the sea surface from earlier satellites such as Nimbus were of poor quality for interpretation of sea surface temperature anomalies. Large instantaneous field of view and large electronic signal noise imposed serious limitations on resolutions in space and time. The situation was made worse by infrared absorption by the atmosphere and clouds obscuring the sea surface.

A remarkable advance in the state-of-the-art of remote sensing in the infrared was made in 1972 with the introduction of NOAA satellites in near-polar, almost circular, sun synchronous orbits at an altitude of 1460 km. These satellites carry a Very High Resolution Radiometer (VHRR) and a Scanning Radiometer (SR). The VHRR visible (0.6-0.7  $\mu$ ) and infrared (10.5-12.5  $\mu$ ) channels collect data with a resolution of 1 km at nadir. The SR is similarly equipped, except for the spatial resolution of 4 km and 8 km for the visible and infrared channels, respectively. The signal noise is also reduced to 0.5-3 °C. Therefore, NOAA satellites have proven valuable tools in detection/or monitoring of eddies, currents, thermal fronts, and upwelling phenomena.

Richardson, Strong and Knauss (1973) studied the drift of a cold cyclonic eddy with a temperature of 16 °C, compared to 24 °C for the Gulf Stream to its west. The eddy shown in Fig. 12(a) was first observed by the infrared radiometer aboard NOAA-1 satellite on April 12, 1971. The NOAA-1 DRIR measurements during the next two days confirmed the existence of this eddy. Three months of observations including bathythermographs taken from several research vessels (Fig. 12(b)) indicate that the eddy slowly drifted southward at an average speed of 1 mi/day until it was absorbed by the Gulf Stream off Florida.

Vukovich (1974) conducted a time series analysis of NOAA-1 sea surface temperature (SST) data off the southeast coast of the United States taken during April 12-22, 1971. He estimated stream functions for the flow which could have produced the observed



FIG. 8. Black and white reproduction of the color-enhanced TIROS III Scanning Radiometer Imagery of Earth obtained from channel 2 ( $8-12\mu$ ) during orbits 56-63 on July 16, 1961. Different shades represent contrasts in temperature from  $225^{\circ}\text{K}$  to  $300^{\circ}\text{K}$  and above.





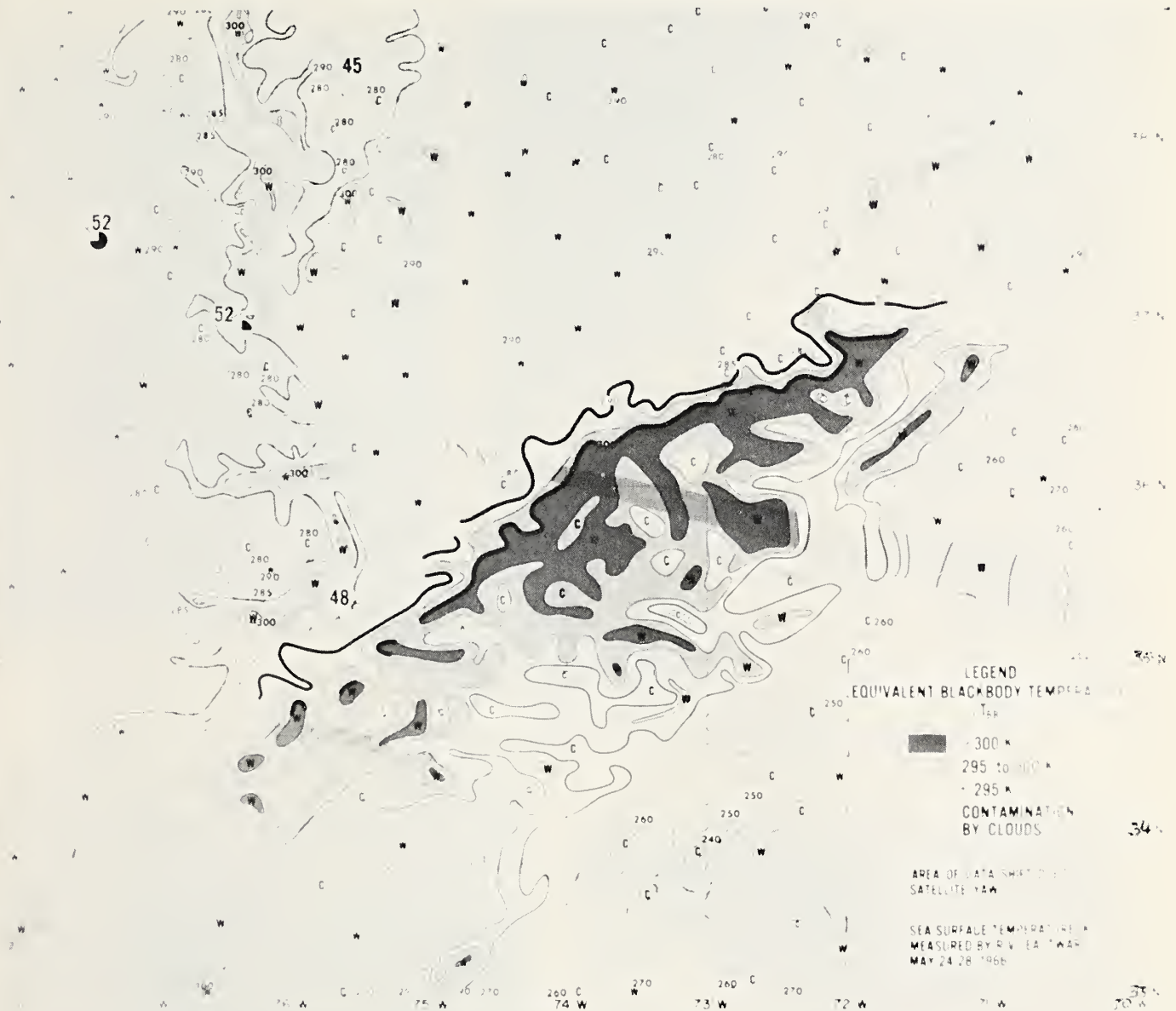


FIG. 10. Remote detection of the Gulf Stream boundary using high-resolution infrared radiometer (HRIR 3.5-4.1  $\mu$ ) aboard Nimbus II satellite during orbits 238/9 on June 2, 1966.

time changes in the SST pattern by advection. Because of the small signal noise, the DRIR data yielded a more detailed analysis than the stored data. The general flow pattern obtained from this technique compared favorably with estimates of the near-shore flow generated by shear stress. However, eddies detected in the Raleigh Bay and Onslow Bay could have been caused either by the influences of the bottom or coastal topography or by instabilities in the shear zone between the Gulf Stream and the shelf water.

From analysis of the NOAA 4 VHRR data for March 26-April 8, 1975 on the SST distribution in the Gulf Stream, Vukovich and Crissman (1978) studied the dynamics of an elliptic eddy with core temperature of 20 °C, compared to 20-22 °C in the

surrounding waters. They observed the eddy encounter the eastern boundary of the Gulf Stream. The entrainment of the warm Gulf Stream waters into eddy's outer fringes intensified the density contrasts, creating a reservoir of potential energy for later conversion to kinetic energy in the region. The cold eddy soon moved away from the Gulf Stream's eastern boundary, and it was not clearly seen by the satellite after April 8, 1975.

*Upwelling Phenomena:* The Sahara Upwelling experiment (SUE) was designed to explore the operational and post-survey uses of direct read-out satellite data to an oceanographic survey. La Violette (1974) reports on the survey phase of SUE carried out during August 18-26, 1973 in which NOAA-2 infrared data, received at a field satellite receiver station lo-



ITOS 1

19 October 1970

0900 G.M.T.

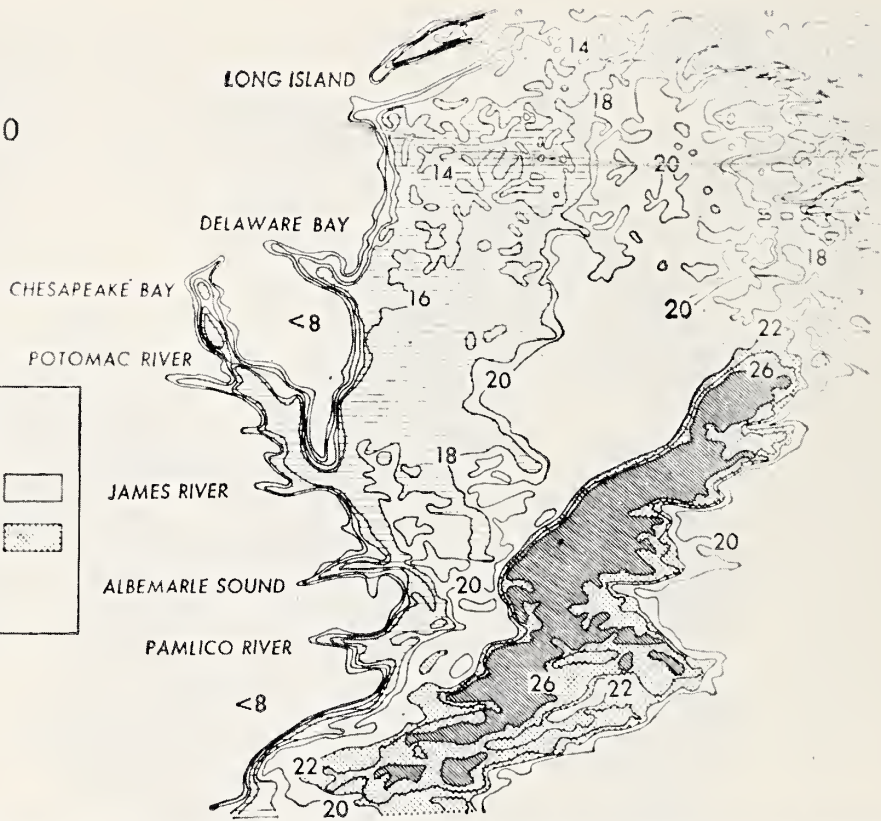
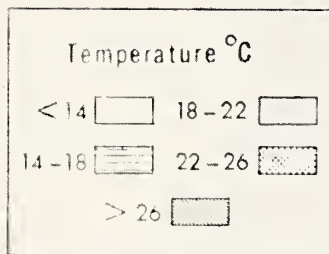


FIG. 11(a) Nighttime DRIR image of the Mid-Atlantic Bight seen from ITOS-1 satellite (after Rao et al., 1971).



FIG. 11(b). New York, Philadelphia, Baltimore and Washington, D.C. revealed as urban heat islands by analysis of the digitized IR data from ITOS-1 satellite at 0900 GMT, October 19, 1970 (after Rao, 1972).



FIG. 11(c). Infrared image of the southeastern United States and Atlantic Ocean from NOAA-1 satellite at 0900 GMT, April 12, 1971. The large cold eddy is across the Gulf Stream from Cape Hatteras (after Richardson et al., 1973).

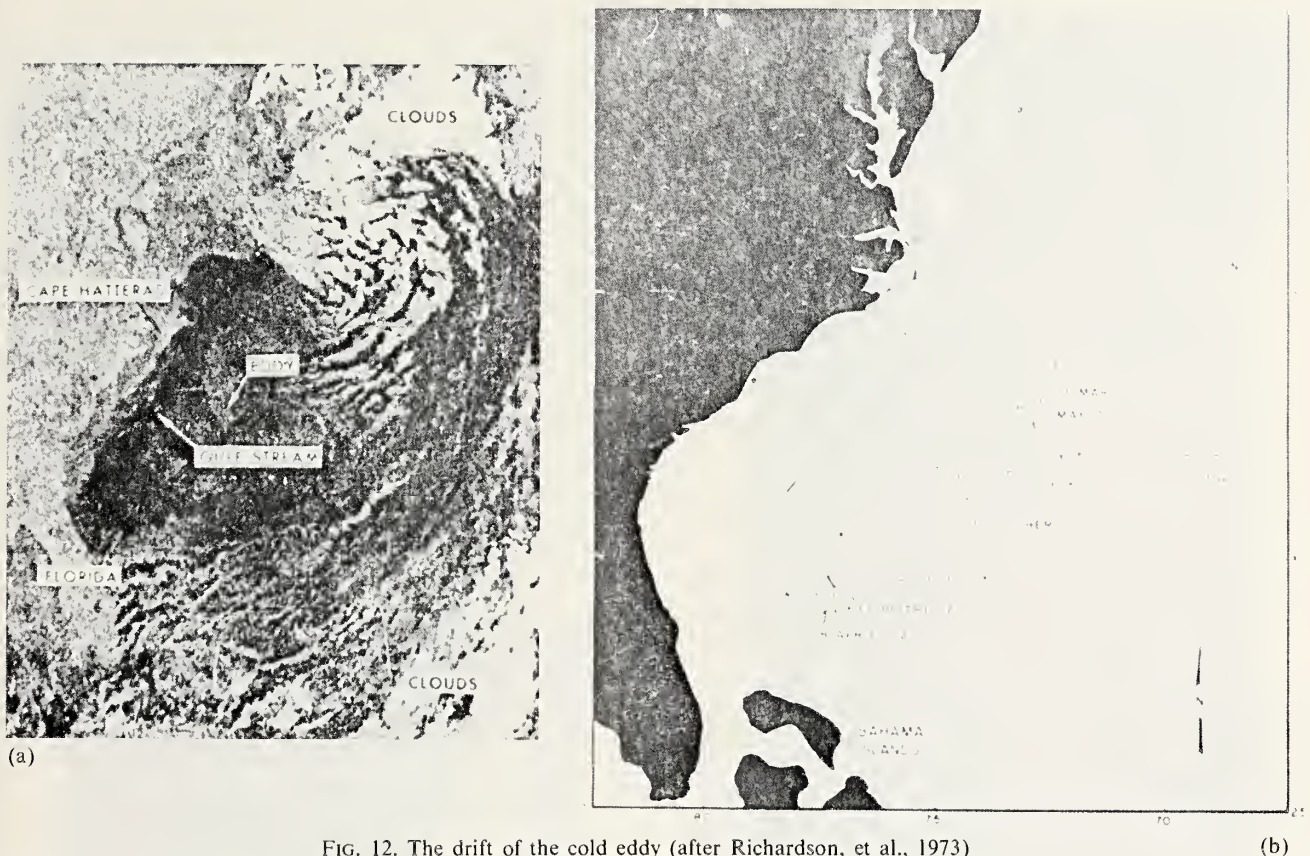


FIG. 12. The drift of the cold eddy (after Richardson, et al., 1973)

(b)

cated on the Gran Canaria Island, aided in directing five flights of a research aircraft over the region's most interesting thermal features.

Fig. 13(a) presents the image of the region off the West Coast of Africa obtained from  $10.5\text{--}12.5\mu$  infrared channel on August 21, 1973. Figs. 13(b), (c) and (d) respectively show a computer enhanced image, numerical data analyzed image, and a schematic presentation of the infrared image. The visible image of the region obtained simultaneously with the infrared, is provided in Fig. 13(e). The simultaneous visible and infrared imagery of the same region helped in distinguishing clouds (seen both in the IR and visible) and upwelled colder water (seen in IR only). The infrared features show a cool feature just south of the Gran Canaria Island, and a warm eddy along the lee coast of the island.

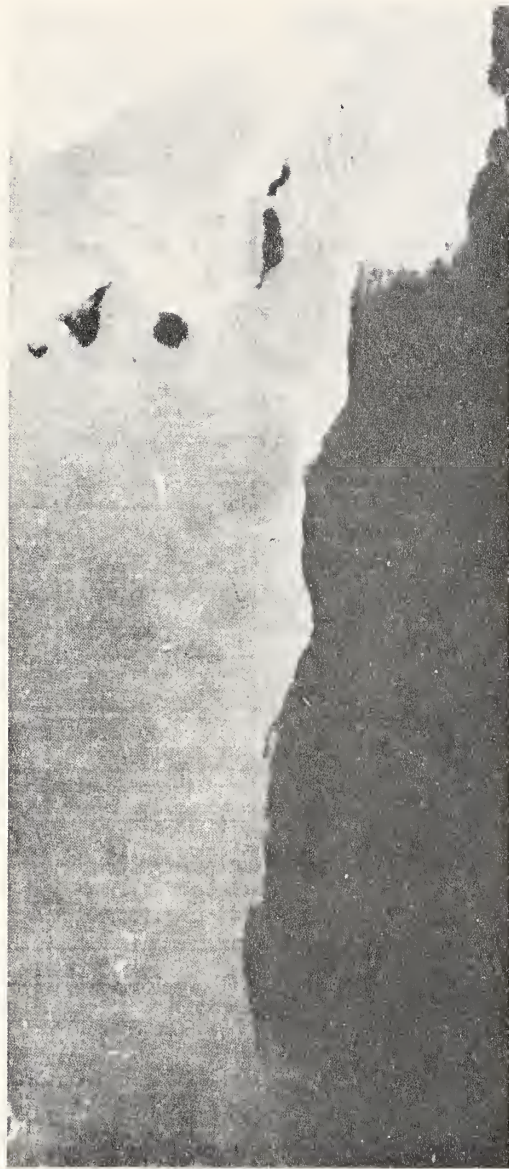
The research aircraft carried airborne radiation thermometer operating in the  $9.5\text{--}11.5\mu$  spectral range, and 300 m airborne expendable bathythermographs. From the post-survey examination of the aircraft and satellite data collected during August 19–26, 1973, La Violette observed upwelling along the coast of the Spanish Sahara, and several cold and warm eddies over a region extending more than 100 km northwest of the coast. The movement and general variability of these features during the survey period reflects on either their short life or periodic occurrence.

An area of intense upwelling was observed north of

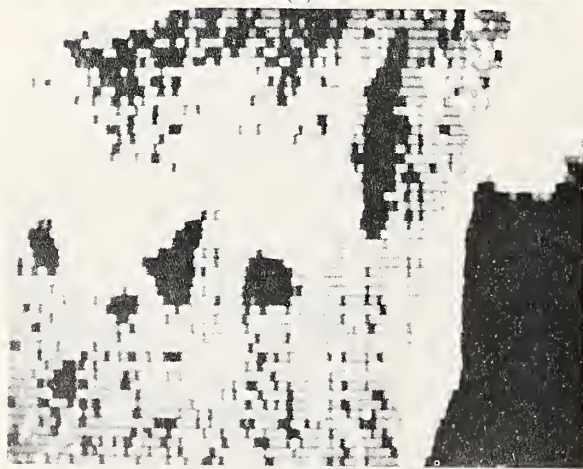
the Cape of Good Hope along the west coast of S. Africa in the NOAA-5 infrared image 2830 (Fig. 14(a)) taken on May 15, 1977. The contours in Fig. 14(b) are used to separate areas of similar SST. The band of warm water ( $18.9^\circ\text{C}$ ), about 50 km north of Cape Town, appears to be a northwestward flowing current.

Stumpf (1975) has studied an interesting case of frequent wind-induced upwellings. During December 1973, there were five separate tehuantepecers with associated upwellings. The first of these is the longest continuous upwelling recorded in recent history. It began on November 29 and lasted through December 3. Fig. 15 shows the nighttime and daytime infrared images of this event. The cool upwelled water is the light gray area that widens southward from the Isthmus. Irregular white areas are cold cloud tops. Four other tehuantepecers of shorter duration followed in quick succession on December 7–9, 10, 11, 16–18, and 22–23. Each of these events was associated with strong winds averaging 20 knots. On December 23, winds became light and variable in direction. As a result, upwelling ceased, and in the process of the return of the current to its normal course, a large circular (160 km in diameter) anticyclonic eddy developed. Thermal patterns of the sequence of alternating daytime and nighttime VHRR images in Fig. 16 clearly delineate this eddy. Another example of wind-induced upwelling and a well-formed anticyclonic westward moving eddy is found in the

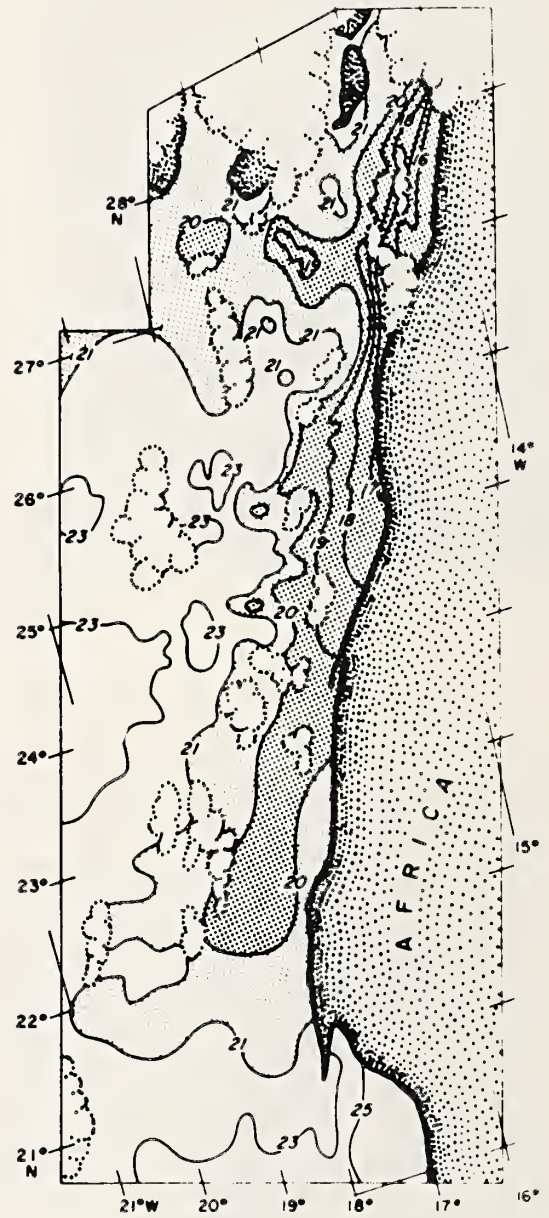




13(a)



13(b)



13(c)

FIG. 13. Imagery and analysis of NOAA-2 VHRR data for the coastal region of upwelling off Spanish Sahara on August 21, 1973: (a) infrared image ( $10.5\text{--}12.5\mu$ ); (b) computer-enhanced infrared image; (c) analysis of numerical infrared data; (d) schematic presentation of infrared data; and (e) visible image (after La Violette, 1974).



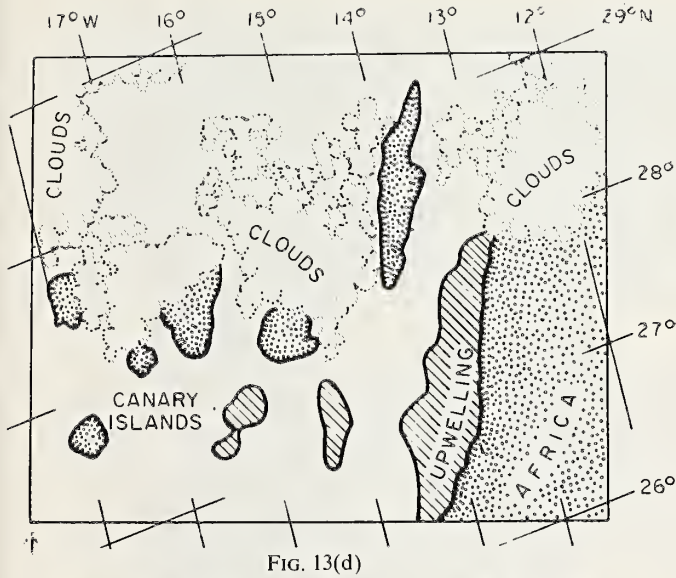


FIG. 13(d)

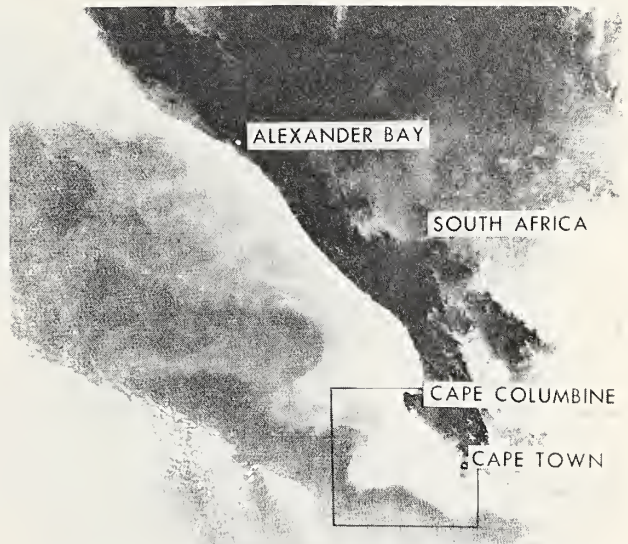
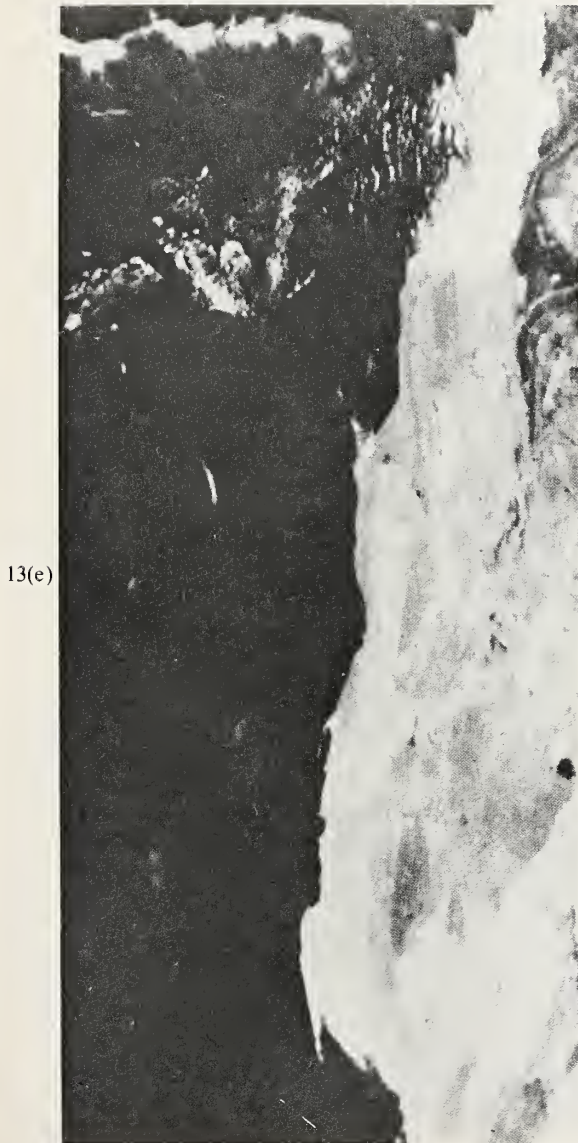


FIG. 14(a). Upwelling along the west coast of S. Africa, north of the Cape of Good Hope as seen in NOAA-5 VHRR infrared image 2830, May 15, 1977.



13(e)

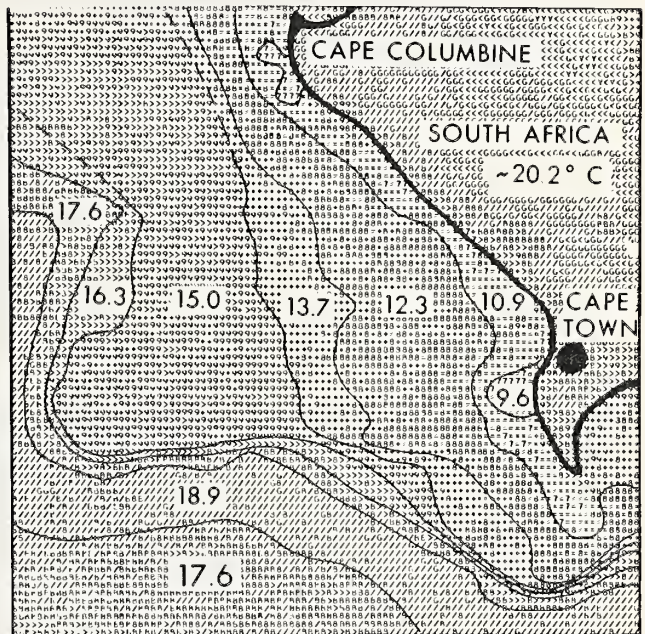


FIG. 14(b). Spatial variation of sea surface temperature for the coastal area in Fig. 14(a).

NOAA-4 VHRR IR image 5590, obtained on February 5, 1976 (Fig. 17). The observed intense SST gradients were as high as  $5^{\circ}\text{C}/\text{km}$ .

*More Currents, Eddies, SST Fronts and Icepacks:* Of the several NOAA-4/5 VHRR IR images of currents, eddies, icepacks and SST fronts studied by Legeckis (1978), we describe the following:

Fig. 18 is the NOAA-5 VHRR IR image 3235 (April 17, 1977) which shows three interesting features of the region off the southeastern United States coast: (i) the meanders and eddies, usually associated with the Gulf Stream; (ii) a seaward deflection of the Gulf Stream south of Charleston, attributed to to-

FIG. 13 cont'd





FIG. 15. NOAA-2 VHRR infrared image of the longest tehuatepecer. Left, nighttime image acquired at 2100 local time; right, daytime image acquired at 0900 local time (after Stumpf, 1975).

pography; and (iii) a wavelike pattern in the Atlantic Subtropical Front, east of Florida. The front is usually observed during the winter and spring months, and begs explanation.

The NOAA-3 VHRR IR image 4721 (November 22, 1974) in Fig. 19(a) shows the Loop Current in the Gulf of Mexico during its northward intrusion cycle. Three months later, a large (300 km) eddy separated from the Loop, and moved westward. The SST pattern of the image is shown in Fig. 19(b). The band of warmest water ( $29^{\circ}\text{C}$ ) appears at the western side of the Loop, and the SST gradient at the Loop's perimeter is  $1^{\circ}\text{C}/\text{km}$ . Until this sighting, the northward intrusion of the Loop was not known to occur during the winter.

Fig. 20 represents the NOAA-5 VHRR IR image 5462 (October 14, 1977). It describes the East Austra-

lian Current moving offshore, south of the Coffs Harbor. The warmest water of the current extends to about 400 km offshore. A warm section of the current and a neighboring region of cooler upwelled coastal water are outlined in the 220-km square box.

The NOAA-4 VHRR IR image 5339 (January 16, 1976, Fig. 21) shows the Brazil Current and a warm eddy which had just separated from the Current, east of the Argentina coast. An intense frontal zone, seen between the Brazil and Falkland currents (between  $38^{\circ}$  and  $40^{\circ}$  S) was observed between September 1975–May 1976. The dynamically active Brazil Current should be an interesting subject for continuous study.

The NOAA-5 VHRR IR image 859 (October 7, 1976) displays the Antarctic Polar Front and an ice-pack to the south of the front in the Drake Passage.

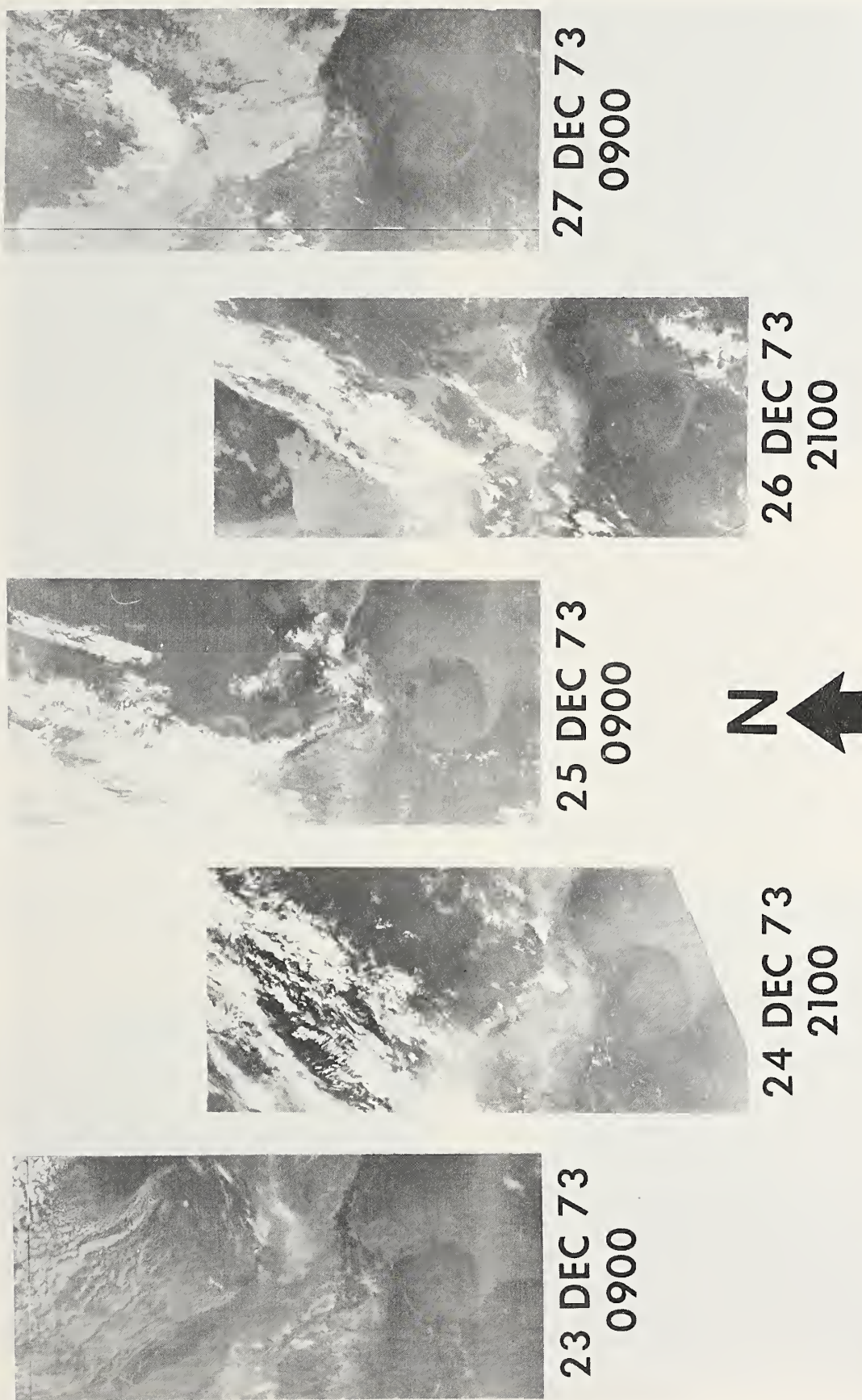


FIG. 16. Sequence of alternating daytime and nighttime VHR infrared image of southern Mexico and the Pacific Ocean (after Stumpf, 1975).



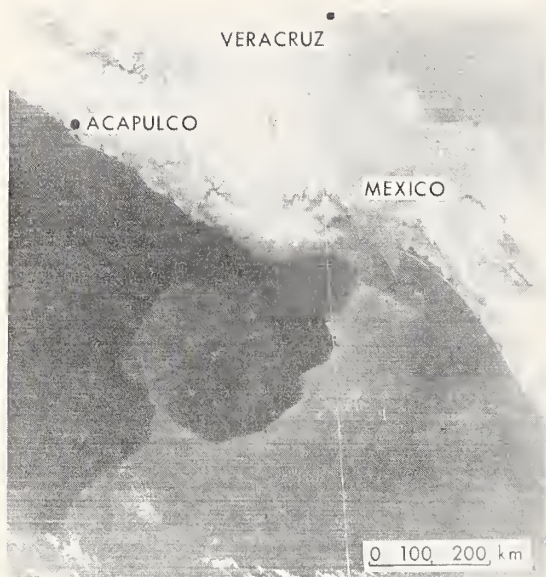


FIG. 17. NOAA-4 VHRR infrared image 5590 of the Gulf of Tehuantepec obtained February 5, 1976.

The SST gradients at the front are most intense ( $0.5^{\circ}\text{C}/\text{km}$ ) during August through November, (Fig. 22).

*Wind Shadows and Tropical Storms:* Analysis of the LANDSAT-1 (ERTS-1) multispectral scanner (MMS) data revealed a feature referred to as the wake or wind shadow effect (Needham, 1976). Fig. 23(a) shows the relatively narrow darker surface feature extending to the northwest of the Bawean Island in the Java Sea on November 2, 1972. The same feature was observed on two other passes on September 27 and December 26, 1972. Fig. 23(b) is a photograph (obtained on March 24, 1973) of the similar effect on the leeside of the St. Vincent Island. This feature extends to the west of the island, and is broader than the one in Fig. 23(a). The phenomenon is observed in four spectral bands:  $0.5\text{--}0.6\mu$ ,  $0.6\text{--}0.7\mu$ ,  $0.7\text{--}0.8\mu$ , and  $0.8\text{--}1.1\mu$ . Observation of the phenomenon in the last band indicates that it is a sea surface effect, with the darker region representing colder wa-

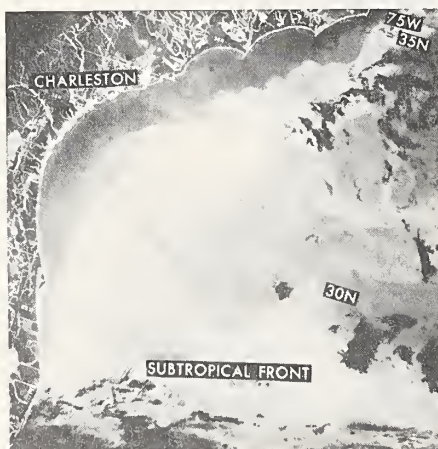


FIG. 18. NOAA-5 VHRR infrared image 3235 of the Gulf Stream and the Atlantic Subtropical Front obtained April 17, 1977 (after Legeckis, 1978).

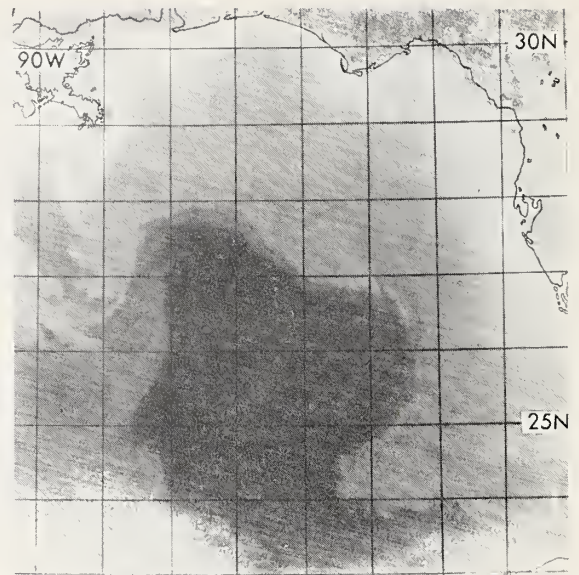


FIG. 19(a). NOAA-3 VHRR IR image of Loop Current in the Gulf of Mexico, November 22, 1974.

ter in the island's wake. The feature is very pronounced at wind speeds lower than  $8\text{ m/s}$ , and is observed to extend as far as  $200\text{ km}$  at a wind speed of  $5\text{ m/s}$ . These features were earlier detected by the VHRR aboard NOAA-2 in the visible band  $0.6\text{--}0.7\mu$ .

Fig. 24(a) provides the analog trace of a single NIMBUS HRIR scan through Hurricane Gladys obtained from orbit 305 on September 18, 1964. A thermal map of the hurricane structured from such scans is shown in Fig. 24(b).

*Heated Land Effects:* An impressive illustration of the surface temperature detail of the mid-Atlantic coastal region is provided by a color-enhanced NOAA-4 VHRR IR image taken at 2000 local time on April 28, 1974 which appeared on the cover of the October 1975 issue of the *Bulletin of the American Meteorological Society*. A black and white reproduction of that photograph is shown in Fig. 25. The

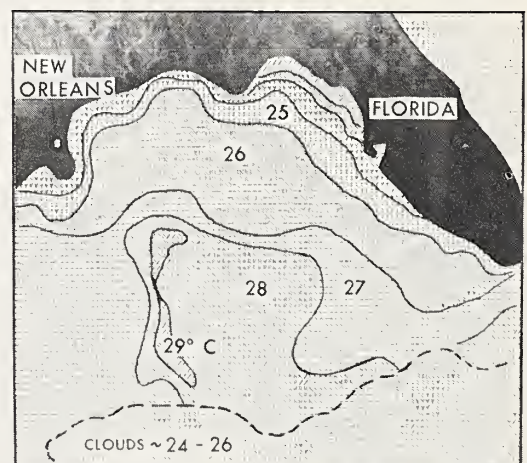


FIG. 19(b). The sea surface temperature pattern of the Loop Current in Fig. 19(a).



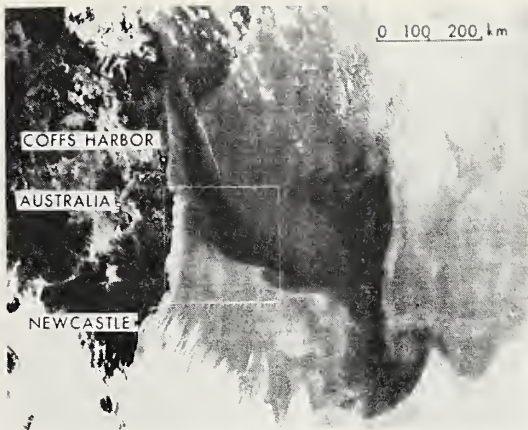


FIG. 20. NOAA-5 VHRR IR image 5462 (October 14, 1977) of the Eastern Australian Current.

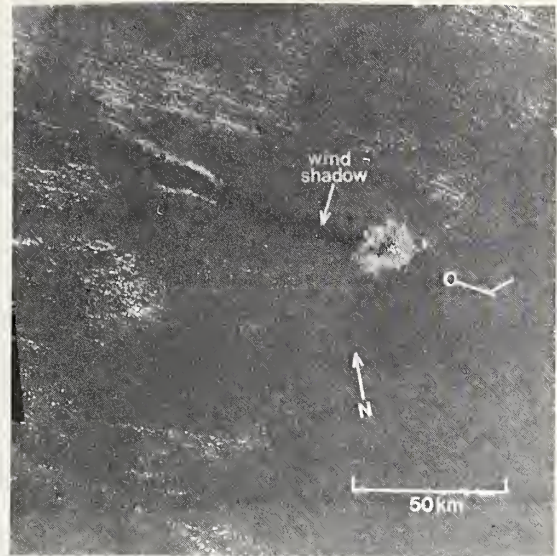


FIG. 23(a). LANDSAT-1 MSS-5 image (E-1102-02093, November 2, 1972) showing wind shadow effect in the lee of the Pulu Bawean Island (after Needham, 1976).



FIG. 21. NOAA-4 VHRR IR image 5339 (January 16, 1976) of the Brazil and Falkland Currents.

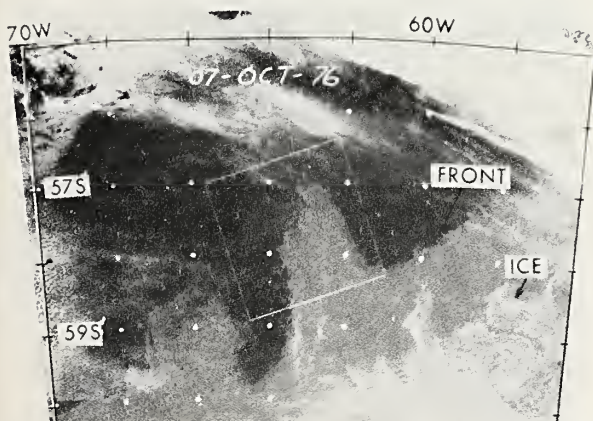


FIG. 22. NOAA-5 VHRR IR image 859 of an antarctic polar front and an icepack in the Drake Passage (October 7, 1976).

image identifies temperatures within  $\pm 1^\circ\text{C}$ ; the darkest region represents a temperature of 20 to 23  $^\circ\text{C}$ , and the lightest shade represents the regions cooler than 6  $^\circ\text{C}$ . The color photograph delineated the thermal structure of the Gulf Stream in 8 temperature intervals. Two eddies are observed with the Gulf Stream ( $T \sim 22^\circ\text{C}$ ): a warm anticyclonic eddy south of Cape Cod and immediately north of the Stream at  $39^\circ 20' \text{ N}$  and  $68^\circ 30' \text{ W}$ ; and a cyclonic cold eddy located east of Cape Hatteras across the stream of the  $34^\circ 40' \text{ N}$  and  $72^\circ 10' \text{ W}$ . The waters inside the Outer Banks of North Carolina along the left-hand edge of the image are at 14  $^\circ\text{C}$ . Urban heat islands associated with Philadelphia, Baltimore, Washington, D.C., and

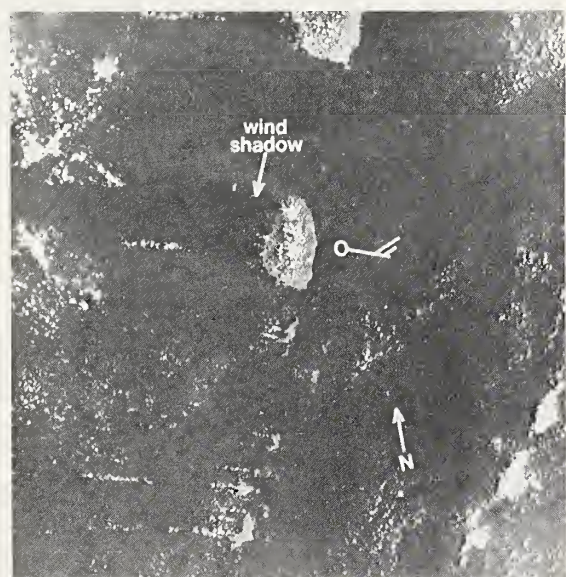


FIG. 23(b). LANDSAT-1 MSS-5 image (E-1224-13560, March 24, 1973) showing the wind shadow effect introduced by the St. Vincent Island (after Needham, 1976).



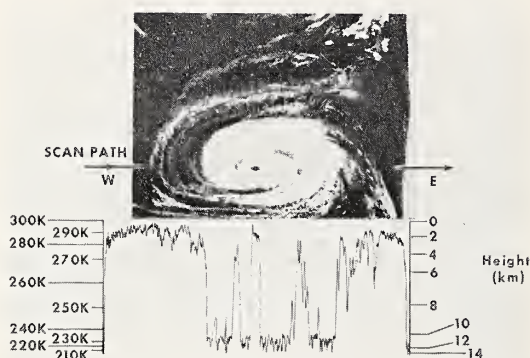


FIG. 24(a). Analog trace of single scan through hurricane Gladys (NIMBUS HRIR orbit 305, September 18, 1964, 0422 U.T.).

Occuquan and Richmond, Va. are also identified in the reproduced image.

The next four figures illustrate examples of possible land use applicability of remote sensing in the infrared. Fig. 26 describes the thermal details of four lower Great Lakes, viz. Michigan, Huron, Erie and Ontario, as seen in NOAA-2 VHRR image obtained at 2100 local time on June 13, 1973. It portrays spring warming of the surface waters, and heat islands associated with several metropolitan areas, including Chicago, Cleveland, Columbus, Detroit, Milwaukee, Rochester and Toronto. Each lake presents interesting new information concerning its surface warming. Cooler waters near the north shores of Lakes Ontario and Erie are due to wind-induced upwelling. Two isolated areas of very warm shoal waters on the north shore and a ribbon of warm water along the southern shore in Lake Erie are prominent. Water

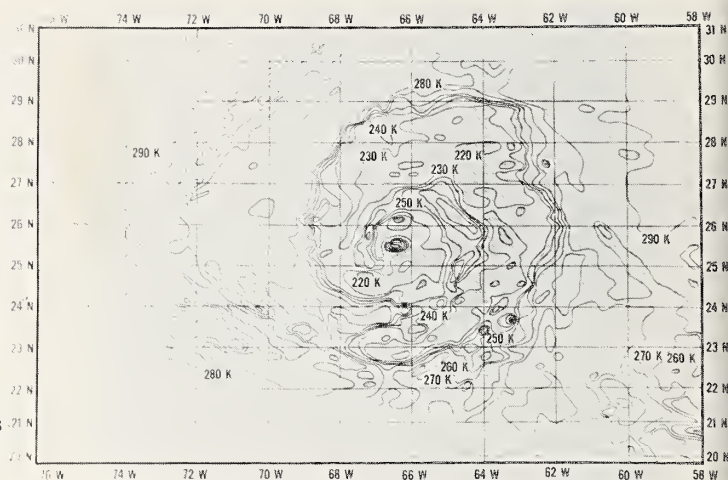


FIG. 24(b). NIMBUS HRIR thermal map of the hurricane Gladys (orbit 305, September 18, 1964).

depth determines which areas in Lake Huron and Michigan warm first. Very warm water is found along the Canadian shoreline, south of Georgian Bay in Lake Huron. Similarly, the shallow Green Bay is much warmer than the proper Lake Michigan.

NOAA-4 VHRR infrared image in Fig. 27 shows an interesting thermal contrast of the cornfields south of Chicago, Illinois, as the melting of snow progressed during the winter of 1976. Similarly, Fig. 28 shows contrasts in thermal response to solar radiation by the ungrazed and overgrazed soils in the Sinai. The observed phenomenon may have a bearing on the formation of deserts along the Mediterranean coast and a cyclical pattern of droughts associated with the movements of the nomadic tribes. Not subjected to grazing by domestic animals, the Negev has a more stable vegetation and dark plant debris condition which are conducive to the heat island effects leading to precipitation. Overgrazing by goats and sheep denudes the soil, renders it more reflective and less absorptive of solar heat. Thus the overgrazed land receives much less rainfall.

Carlson, Augustine and Boland (1977) provide an analysis of the surface temperature for the Los Angeles areas in Figs. 29(a) and (b), derived from NOAA-3 VHRR IR measurements (a) at 0856 and (b) 1957 Pacific Standard Time on March 29, 1975. The VHRR visible photographs show cloudless conditions for this day. The letters N, H, P and S designate geographical areas. The region of maximum temperature is generally close to the central business and high-density residential area (H). During the morning, the highest temperature ( $\sim 26^{\circ}\text{C}$ ) occurred over the industrial zone (N). By evening, the maximum temperature ( $\sim 16^{\circ}\text{C}$ ) had shifted slightly toward the region H. Smaller daytime variations in temperature were observed in Palos Verdes Peninsula (P) and Santa Monica Mountains (S).

### Conclusions

Thermal anomalies in oceans range from about  $2^{\circ}\text{C}$  for the eddies to about  $10^{\circ}\text{C}$  for the Gulf Stream.



FIG. 25. NOAA-4 VHRR IR image of the Mid-Atlantic coastal region of the United States, obtained on April 28, 1974, shows Gulf Stream features and urban heat islands of neighboring metropolitan areas.



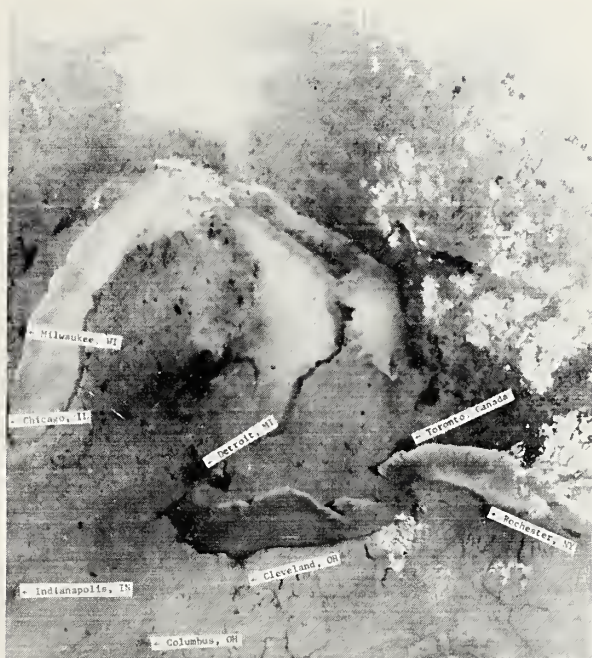


FIG. 26. Spring warming in the lower Great Lakes area and urban heat islands associated with Chicago, Cleveland, Columbus, Detroit, Milwaukee, Rochester, and Toronto as seen by NOAA-2 VHRR IR at 2100 local time on June 13, 1973.

Similarly, the urban-rural contrasts in temperature, both on the macro- and micro-scales, are on the order of 2 to 8 C°. These thermal contrasts influence the nature and quality of the local atmospheric and marine environments and regional climatology.

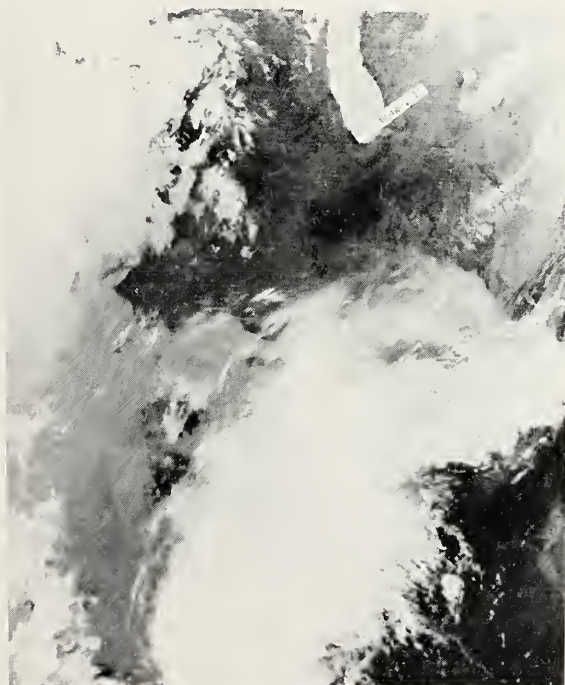


FIG. 27. Melting of snow and growth of corn in fields south of Chicago during the winter of 1976 as seen by NOAA-4 VHRR infrared channel.



FIG. 28. Separation between grazed and ungrazed land in the Negev area of the Sinai as viewed by LANDSAT-1.

The surface-based data collection activities related to oceanic and urban thermal anomalies are very tedious, time consuming, not simultaneous, and often expensive. The infrared radiometers aboard low-flying aircraft have demonstrated feasibility of achieving good resolution, but, these also suffer from a limited range of coverage, utilization, and lack of continuous monitoring. Instrumented satellites provide automatic monitoring of a large segment of our globe with simultaneous observations of each region repeated at regular intervals. This permits the diurnal and seasonal studies of certain terrestrial phenomena.

Both urban and thermal anomalies have comparable magnitudes, and the advanced high resolution radiometers aboard Nimbus and NOAA satel-



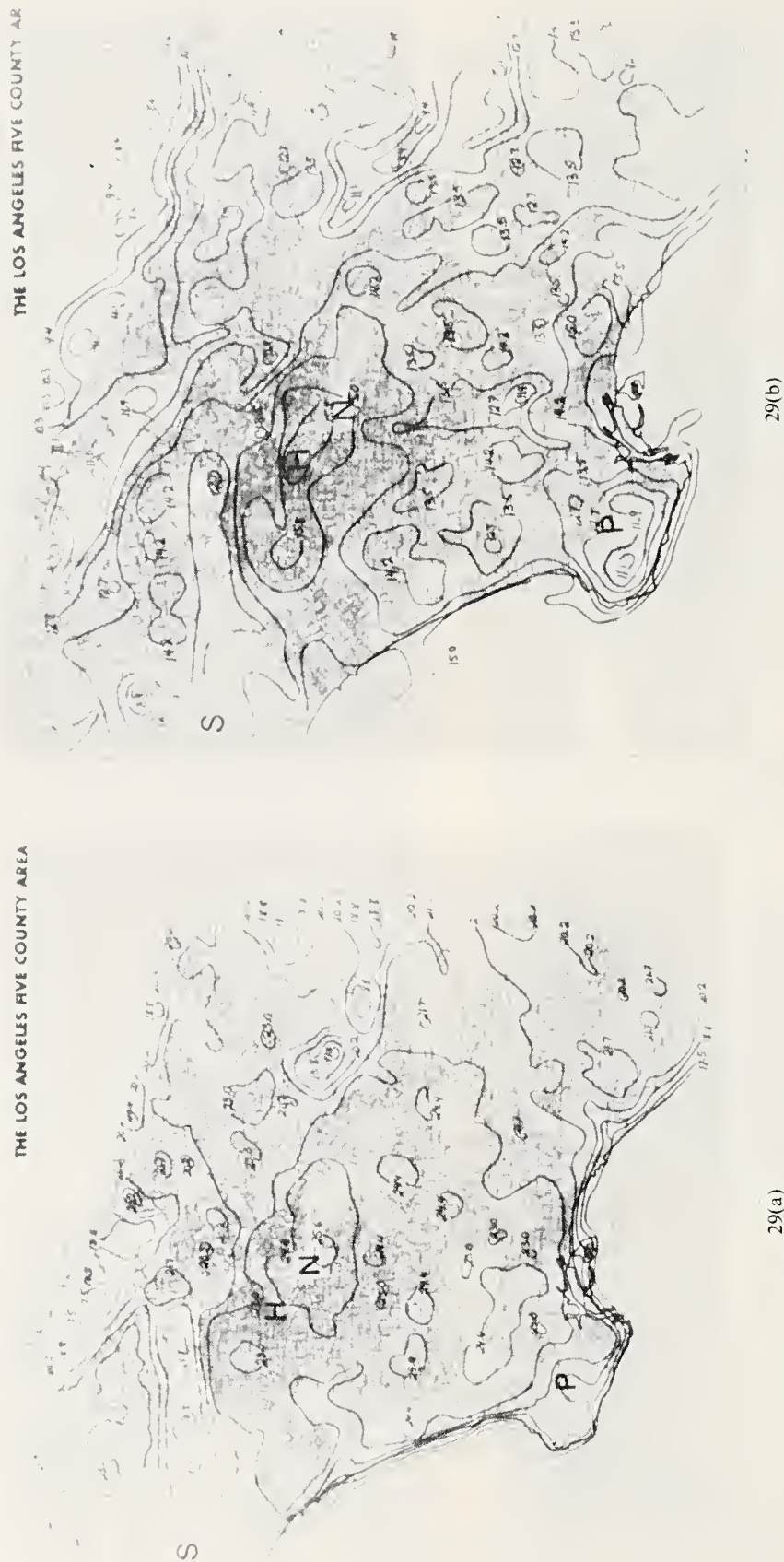


FIG. 29. Los Angeles as an urban heat island based on analysis of NOAA-3 VHRR IR measurements at (a) 0856 PST, and (b) 1957 PST on March 29, 1975. The letters refer to geographical location: N-industrial zone; H-high density residential and central business; P-Palos Verdes Peninsula; S-Santa Monica Mountains.

lites are capable of sensing surface temperature with an accuracy of 1 to 2 C° and a spatial resolution of 1 km. This accuracy is marred by uncertainties introduced by signal noise (electronic) and spatial variations in water vapor, aerosols, and surface emissivity of an urban area which is usually a mixture of industrial and varying density residential areas, paved roads and concrete parking lots, parks and recreational areas, etc. For these reasons, the reports of sighting sea surface temperature anomalies are more abundant than those on urban heat islands.

For thermal data to be of value in land-use applications, we need a resolution better than 1 C° in temperature and 1/4 km in surface area. Remote sensing of thermal contrasts with resolutions better than 1/2 C° and 1/6 km are desirable for detection and monitoring of air and water quality, rescue missions in situations of hazard, agriculture and forestry, and fisheries. The TIROS N and LANDSAT (ERTS) satellites are expected to provide IR data of improved quality and better resolution. For example, the infrared data is expected to have a thermal resolution of 0.5 C° and spatial resolution of 240 m. With these resolutions in mind, Chopra and Trafford had proposed in 1975 a thermal sensing of the eastern seaboard with the objective for observing anomalies associated with the cities of Baltimore, Norfolk, Philadelphia, Richmond, Salisbury and Washington, D.C.

These cities represent a wide variety of city conditions. For example, the city of Salisbury represents the class of a small town with uniformly sandy soil and flat terrain surrounded by farm/forest land. This city should provide an opportunity to study the thermal influence of a compact single land use application in an otherwise homogeneous geographical background. This is the simplest test city, and its study shall help establish the analytical procedures to be followed in analysis of other test cities. Philadelphia, on the other hand is an example of a large spread-out city with slightly rolling terrain covered with a variety of structures interspersed by parks and water mass.

Norfolk is a medium-sized city with an infra-structure of low level land-use segments, open spaces, parks and water masses. The city is located in a meteorological shelter zone—it is relatively safe from the severe meteorological events from the North, South, or the Midwest. The city has an atmosphere which is neutral or stable about 80% of the time, and the prevailing winds have only a slight preference for the NEE-SSW directions.

Richmond is a medium-sized city with a rolling (slightly hilly) terrain and a polluted James River flowing through it. The neighboring metropolitan cities of Baltimore and Washington are large and dense with a string of smaller suburban communities between them. These three cities, together with Phila-

delphia, are exposed to severe weather conditions. All four cities are expected to introduce complex patterns of thermal anomalies.

Various observed thermal anomalies described in this article support the feasibility of such a study. The long-term benefits would be the understanding of (1) the relationship between various land-use projects and thermal anomalies introduced by the same, (2) the impact of these man-induced anomalies on regional climate and environment. A better understanding of these features would find applications in more judicious land use decision-making, and better design and planned growth of our cities, particularly on the DELMARVA Peninsula.

### Acknowledgments

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### References

- Carlson, T. N., Augustine, J. A., and Boland, F. E. (1977): Potential applications of satellite temperature measurements in the analysis of land use over urban areas. *Bull. Am. Meteorol. Soc.* **58**, 1301–1303.
- Chopra, Kuldeep P. (1973): Atmospheric and oceanic flow problems introduced by islands. *Adv. Geophys.* **16**, 297–421.
- Garstang, M., Tyson, P. D., and Emmitt, G. D. (1975): The structure of heat islands. *Rev. Geophys. Space Phys.* **13**, 139–165.
- La Violette, Paul E. (1974): A satellite-aircraft thermal study of the upwelled waters off Spanish Sahara. *J. Phys. Ocean.* **4**, 676–683.
- Legeckis, R. (1978): A survey of worldwide sea surface temperature fronts detected by environmental satellites. *J. Geophys. Res.* **83**, 4501–4522.
- Needham, B. H. (1976): Observation of wind-induced sea surface feature off Pulu Bawean, Java, from LANDSAT-1. *Bull. Am. Meteorol. Soc.* **57**, 444–448.
- Rao, P. K. (1972): Remote sensing of urban heat islands from an environmental satellite. *Bull. Am. Meteorol. Soc.* **53**, 647–648.
- Rao, P. K., Strong, A. E., and Koffler, R. (1971): Gulf Stream and Middle Atlantic Bight: complex thermal structure as seen from an environmental satellite. *Science* **173**, 529–530.
- Richardson, P. L., Strong, A. E., and Knauss, J. A. (1973): Gulf Stream eddies: recent observations in the Western Sargasso Sea. *J. Phys. Ocean.* **3**, 297–301.
- Stumpf, Harry G. (1975): Satellite detection of upwelling in the Gulf of Tehuantepec, Mexico. *Mariners Weather Log* **19**, 71–74.
- Vukovich, F. M. (1974): The detection of nearshore eddy motion and wind-driven currents using NOAA-1 sea surface temperature data. *J. Geophys. Res.* **79**, 853–860.
- Vukovich, F. M., and Crissman, B. W. (1978): Further studies of a cold eddy on eastern side of the Gulf Stream using satellite data and ship data. *J. Phys. Ocean.* **8**, 838–845.



# An Annotated List of the Odonata of Southeastern Virginia

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**Abstract**—A total of 61 species of odonata in 31 genera is recorded from southeastern Virginia. All of the families except the Petaluridae are represented. Flight season and habitat preference (where known) are presented for most species.

## Introduction

The author has made many collections of odonata in southeastern Virginia as a part of a general study of the aquatic insects of the area. Additional collections have been made by several students as part of a special study of the odonata of the dismal swamp and the surrounding area. Since it is desirable that these distribution records be available for the development of a section on odonata in the "Insects of Virginia" series, the following list, a compilation of these records as well as the few literature records available for the area, is presented.

The area collected includes Sussex, Southampton and Isle of Wight counties and the cities of Norfolk, Portsmouth, Virginia Beach, Chesapeake and Suffolk. Distribution within southeastern Virginia as well as the first and last dates on which adults have been collected are given. In addition, notes on abundance and, where possible, habitat preference are given.

## Suborder Zygoptera

### Family Calopterygidae

#### *Calopteryx maculatum* (Beauvois)

Isle of Wight and Southampton Counties and the city of Suffolk, July 2 to August 12. Restricted to ravine bordered streams. Because of this habitat restriction, this species is found only in isolated areas of southeastern Virginia, but usually is abundant where found.

### Family Lestidae

#### *Lestes disjunctus australis* Walker

Isle of Wight County and the cities of Suffolk, Norfolk and Virginia Beach, April 17 to August 19.

This species is most abundant at the margins of open ponds.

#### *Lestes rectangularis* Say

Virginia Beach, May 25 to September 27. This species was common beside the empoundments and woodland pools in the Back Bay National Wildlife Refuge.

#### *Lestes viglax* Hagen

Suffolk, September 17 (Gloyd, 1951); Sussex County, June 6-21.

### Family Coenagrionidae

#### *Amphiagrion saucium* (Burmeister)

Norfolk, June 9.

#### *Anomalagrion hastatum* (Say)

Norfolk, Suffolk, and Virginia Beach, April 17 to September 13. This is one of our commoner species but is easily overlooked because of its small size and low flying habit. It is easily recognized in the field by its small size, yellow abdomen, and by the stigma of the male, which is set back from the front margin of the wing.

#### *Argia apicalis* (Say)

Norfolk, Suffolk, and Isle of Wight County, June 1 to September 7.

#### *Argia tibialis* (Rambur)

Suffolk, Isle of Wight and Southampton Counties, June 13 to August 5

#### *Chromagrion conditum* (Hagen)

Sussex County, June 21

#### *Nehalennia integricollis* Calvert

Recorded by Gloyd (1951) from Suffolk on September 17.

#### *Enallagma aspersum* (Hagen)

Suffolk, August 19

#### *Enallagma civile* (Hagen)

Suffolk and Virginia Beach, June 8 to July 11

#### *Enallagma divagans* Selys

Suffolk, reared from a nymph collected in the Dismal Swamp on February 19, 1975.

#### *Enallagma dubium* Root

Recorded by Gloyd (1951) from Suffolk on September 14.

#### *Enallagma durum* (Hagen)

Norfolk, Suffolk, and Virginia Beach, April 17 to June 11.

#### *Enallagma geminatum* Kellicott

Suffolk (Gloyd, 1951); Sussex County, June 6 to September 13.

#### *Enallagma signatum* (Hagen)

Suffolk and Sussex County, June 21 to September 13.

*Enallagma traviatum* Selys

Isle of Wight County, June 1.

*Ishnura posita* Hagen

Norfolk, Suffolk, and Virginia Beach, April 17 to September 13.

*Ishnura ramburi* Selys

Norfolk, Isle of Wight County, June 1-15.

**Anisoptera**

## Family Gomphidae

*Gomphus exilis* Selys

The city of Suffolk and Isle of Wight County, April 10 to June 6. Nymphs are found at the margins of muddy streams and ponds. The adult is among our earliest spring species and is abundant in the Dismal Swamp during its flight season.

*Gomphus villosipes* Selys

Isle of Wight County, June 1. Males of this species were collected sitting on sandy areas at stream margins.

## Family Cordulegasteridae

*Cordulegaster obliquus* (Say)

This record is based on two nymphs collected from Washington Ditch in the Dismal Swamp during February. No adults have been collected.

## Family Aeschnidae

*Anax junius* Drury

Norfolk, Portsmouth, Suffolk, and Virginia Beach, June 8 to August 19. This large, fast flying species is frequently seen in all parts of southeastern Virginia.

*Basiaeschna janata* Say

Suffolk, May 16. This species is represented in our collections by a single specimen collected from the Dismal Swamp.

*Boyeria vinosa* Say

Norfolk, Suffolk, and Southampton County, September 12-15.

*Epiaeschna heros* Fabricius

Suffolk and Isle of Wight County, June 1 to August 12. This species is common throughout the summer, but is quite wary and difficult to collect during most of its flight season.

*Gomphaeschna antilope* (Hagen)

Norfolk and Suffolk, April 16 to May 16. This and the following species are our earliest spring species. They are probably more widespread than the distribution data indicate since our early spring collections are predominately from the Dismal Swamp.

*Gomphaeschna fuscillata* Say

Chesapeake and Suffolk, April 18 to May 16.

*Nasiaeschna pentacantha* Rambur

Isle of Wight County, June 1.

## Family Macromiidae

*Didymops transversa* (Say)

Suffolk, April 11 to May 16. Also reared from nymphs collected in Isle of Wight County on January 5. In addition to the adult and rearing records, this species has been recorded from nymphal specimens taken at the margins of Washington Ditch in the Dismal Swamp.

*Macromia georgina* (Selys)

Suffolk, August 15. These large, wary, fast flying dragonflies were frequently seen but rarely collected

as adults. Nymphs have been collected on several occasions from small lakes in Suffolk and Isle of Wight County.

## Family Corduliidae

*Epicordulia princeps* (Hagen)

Sussex County, July 10. Males usually patrol large areas over lakes and ponds. Females have been observed in large numbers emerging from wooded areas at dusk.

*Somatochlora filosa* (Hagen)

Suffolk, August 12.

*Somatochlora linearis* (Hagen)

Suffolk, August 5 to September 14.

*Tetragoneuria cyanosura* (Say)

Suffolk, Virginia Beach, and Isle of Wight County, April 10 to May 19. This is one of our early spring species in the Dismal Swamp. Nymphs are frequently found at the margins of slow moving ditches and pools.

## Family Libellulidae

*Camacria grvida* (Calvert)

Virginia Beach, June 27 to September 8. In southeastern Virginia this species has been collected only on the Back Bay National Wildlife Refuge at the margins of marsh empondments and canals.

*Celethimis elisa* (Hagen)

Norfolk and Suffolk, July 7 to August 19.

*Celethimis eponia* (Drury)

Norfolk, June 11.

*Celethimis monomelaena* Williamson

Sussex County, June 21. Some specimens show characteristics which are intermediate between this species and *Celethimis fasciatus*.

*Erythemis simplicollis* (Say)

Norfolk, Suffolk, Virginia Beach, and Isle of Wight and Sussex Counties, June 11 to October 6. This is our commonest dragonfly and occasionally is seen swarming in large numbers. The adults are usually seen patrolling the margins of larger pools and marshes, but specimens are also frequently encountered in areas far removed from water.

*Erythrodiplax berenice* (Drury)

Norfolk, Suffolk, Virginia Beach, and Sussex County, June 11 to September 16.

*Erythrodiplax miniscula* (Rambur)

Norfolk, July 9-11.

*Libellula axilena* Westwood

Norfolk, Suffolk, and Virginia Beach, June 8 to August 19.

*Libellula cyanea* Fabricius

Norfolk, Suffolk, and Isle of Wight County, May 16 to July 7. The color pattern of the wings of some specimens (particularly the Isle of Wight material) is typical of the color pattern expected on *Libellula commanche*, a western species.

*Libellula flavida* Rambur

Virginia Beach, May 20 to July 2.

*Libellula incesta* Hagen

Norfolk and Suffolk, July 9 to August 19.

*Libellula luctosa* Burmeister

Norfolk, July 7-11.

*Libellula needhami* Westfall

Norfolk and Suffolk, June 11 to August 19.

*Libellula semifasciata* Burmeister

Norfolk, Suffolk, and Virginia Beach, July 7 to



August 19.

*Libellula vibrans*

Suffolk and Virginia Beach, July 20 to August 5.

*Pachydiplax longipennis* (Burmeister)

Norfolk, Suffolk, Virginia Beach, and Sussex County, June 11 to August 12.

*Pantala flavescens* (Fabricius)

Chesapeake, Norfolk, Suffolk, Virginia Beach, and Isle of Wight County, July 2 to September 12. This circumtropical species is frequently seen patrolling in areas far from water. We have never seen it swarming in Virginia as it does in more southern states.

*Pantala hymenea* (Say)

Norfolk, September 21-26.

*Perithemis tenera* (Say)

Norfolk, Suffolk, Virginia Beach, and Isle of Wight County, May 31 to July 3. This little, sexually dimorphic species is usually seen at the margins of small lakes and ponds.

*Platemis lydia* (Drury)

Norfolk and Suffolk, April 22 to August 12. This species was frequently seen flitting about at the margins of ponds and lakes with emergent vegetation and was also frequently encountered in open sunny areas far from water.

*Sympetrum ambiguum* (Rambur)

Suffolk, September 1-20. All of our specimens have been collected in the Dismal Swamp.

*Sympetrum vicinum* (Hagen)

Suffolk, September 20. A single specimen was collected at the margin of Western Branch Lake.

*Tramea carolina* (Linneus)

Gloyd (1951) records this species from Suffolk on September 14.

*Tramea lancerta* (Hagen)

Norfolk and Suffolk, July 9 to August 5.

*Tramea onusta* (Hagen)

Norfolk, Suffolk, and Virginia Beach, June 8 to August 9.

### Discussion

A total of 61 species of odonata in 31 genera is recorded from southeastern Virginia. All of the North American families of odonata except the Petaluridae are represented. Despite this extensive listing, several species which would be expected to occur on the southeastern coastal plain of Virginia have not been collected. *Enallagma minisculum* has been recorded from Nova Scotia to North Carolina (Tennessen and Knopf, 1975) and is recorded by Cuyler (1968) as abundant in North Carolina. It has not yet been collected in southeastern Virginia although suitable habitats do occur here.

In addition, the damselfly *Nehalennia integricollis* was recorded by Gloyd from the Suffolk area but the author has been unable to collect this species.

The distinction between *Tramea carolina* and *T. onusta* is difficult. After an examination of genitalia and wing characters, we have called all of our specimens *T. onusta*. Gloyd (1951), however, records *T. carolina* from the Suffolk area, and that species may occur in southeastern Virginia.

### Literature Cited

- Cuyler, R. D. (1968): Range Extensions of Odonata in Southeastern States. *Entomological News* 79, 29-34.  
 Gloyd, L. K. (1951): Records of Some Virginia Odonata. *Entomological News* 62, 109-114.  
 Tennessen, K. J. and Knopf, K. W. (1975): Description of the Nymph of *Enallagma minisculum* Odonata: Coenagrionidae. *Florida Entomologist* 58, 199-201.

# A Dense Plasma Ultraviolet Source

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dine lasers for which output power is limited, in practice, by the intensity of the uv pump source. The iodine laser is important because of its potential use in producing solar energy conversion in space and laser-fusion reactors.

Gusinow (1975) has investigated the spectral output of high current xenon flashlamps with the addition of Cd and Zn *dopants*. The *dopants* resulted in a factor of two to three enhancement in the spectral output, but the maximum number of shots was severely limited due to the *dopant* migration. High-current surface-discharge sparks were investigated by Beverly and Barnes (1977), who claimed several advantages, including high spectral efficiencies, improved life expectancies, and suitability for use in multiple array configurations. However, such a source has not been applied to iodine laser pumping, nor has the coupling efficiency been determined. The xenon flashlamp and the surface spark sources share a common disadvantage in that their temperatures ( $\sim 1$  eV) are not raised appreciably by increasing either current or working gas pressures. Due to the current path along the surface of the lamp, the life expectancy of the lamp is, in addition, severely limited at such elevated power operation. Exploding wires have been used to pump an iodine laser (Borovich et al., 1975). Although high overall efficiencies are possible with this scheme, poor laser beam quality is unavoidable due to shock-wave induced turbulence, and annular beam profiles present limited applications.

Recently, the intense uv emission from a dense plasma focus apparatus was studied (by Lee and Williams, 1977), and advantages in power output, life expectancy and availability of spectral selections in the uv, vacuum-uv, and soft x-ray region have been recognized. While this apparatus provides an intense point source of plasma with a high temperature of up to a few keV, it is difficult to use it to form a multiple array of such sources. A new and novel geometry, which eliminates such limitations while maintaining the same mechanism for dense-plasma production, is presented together with the results of preliminary investigation on uv emission from the device. The new geometry is called a hypocycloidal-pinch or HCP and was originally developed for production of

**Abstract**—The intense ultraviolet (uv) emission from the NASA Hypocycloidal-Pinch (HCP) plasma was investigated. The HCP consists of three disk electrodes whose cross section has a configuration similar to the cross section of a Mather-type plasma focus. A pair of plasma foci ( $T_e \sim 1$  keV,  $n_e \sim 10^{16} \text{cm}^{-3}$ ) is produced when the maximum compression of the current sheets occurs in the center hole of the apparatus. The plasma foci were produced in deuterium, helium, xenon, and krypton gases in order to compare their emission characteristics. Time-integrated spectra in the wavelength range from 200 nm to 350 nm and temporal variations of the uv emission were obtained with a uv spectrometer and a photomultiplier system. The spectral intensities ( $>100$  MW) of the plasma were determined by photographic comparisons with a standard carbon arc source.

Some modifications to enhance uv emission in the iodine-laser pump band (250 to 290 nm) and preliminary results produced by these modifications are presented. Also, the advantages of the HCP as a uv source over use of conventional xenon lamps with respect to power output limit, spectral range, and lifetime are discussed.

## Introduction

Improved laser pumping sources in the ultraviolet (uv) range of the electromagnetic spectrum are presently being sought in an effort to increase the power output of photodissociation lasers, particularly io-



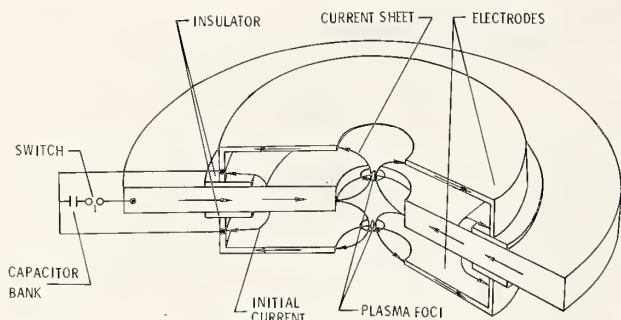


FIG. 1—A cutaway view of the hypocycloidal pinch device. The arrows indicate current flows and the magnetic induction caused by the current.

plasmas with parameters characteristic of thermonuclear fusion reactors (Lee et al., 1977).

### Hypocycloidal Pinch

The hypocycloidal-pinch device consists of three disk electrodes as a radical improvement over the coaxial type of plasma-focus device. Figure 1 shows the cutaway view of the HCP device which can be visualized as formed by the cross section of the coaxial plasma-focus device rotated about an axis situated in front of, and perpendicular to, the center electrode. The lower and upper current sheets launched from the insulators advance radially toward the center hole, where they subsequently collapse and interact with each other. The collapse of the current sheets is timed so that the maximum current occurs when the sheets reach the edges of the center hole to form strong pinches on the axis. The pinches produce a pair of dense plasma foci, each of which resembles a Filippov-type plasma focus (Filippov et al., 1962). However, the azimuthal magnetic field behind the current sheets in the upper and lower chambers are antiparallel, and a magnetic neutral plane is formed between them. Therefore, the plasma foci are forced into the midplane, resulting in a volume of the dense plasma with hypocycloidal (or spindle cusp) boundaries as shown.

It is anticipated that the HCP will offer improvements over the coaxial plasma focus in (1) a longer plasma life, (2) larger plasma volume, (3) access for additional heating by laser or electron beams, and (4) scalability with multiple arrays.

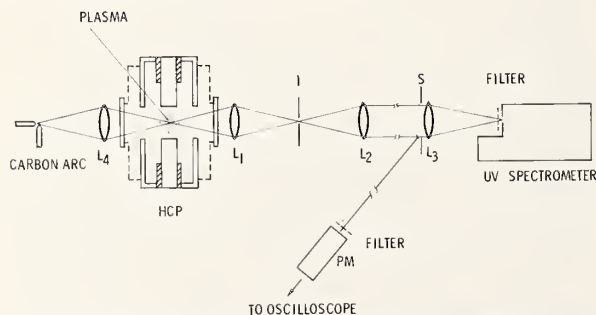


FIG. 2—Experimental arrangement for uv emission measurements.  $L_1$ ,  $L_2$ ,  $L_3$ ,  $L_4$  are lenses; I, iris; S, shutter, and PM, photomultiplier.

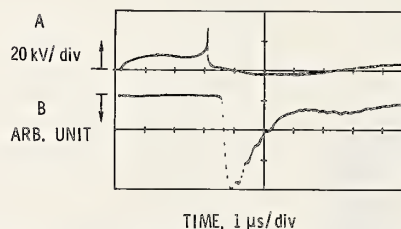
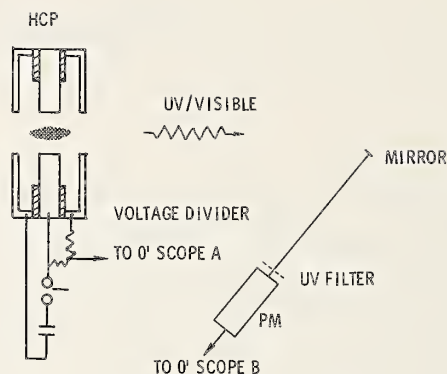


FIG. 3—Comparison of temporal variation of HCP electrode voltage (A) and uv emission (B).

The results of the preliminary investigation of the HCP show that the collapse fronts of the current sheets are well organized and dense plasma foci are indeed produced on the axis with radial stability in excess of  $5 \mu\text{sec}$ . A plasma density greater than  $10^{18} \text{ cm}^{-3}$  was determined with Stark broadening and  $\text{CO}_2$  laser absorption. Essentially, complete absorption of a 50-J  $\text{CO}_2$  laser beam has been observed. A plasma temperature of approximately one keV is measured with differential transmission of soft x rays through thin foils. The details of these results have been reported elsewhere (Lee et al., 1977).

### Experiment and Results

To investigate the ultraviolet emission from the HCP plasma, an experimental setup as shown in Figure 2 was used. The volume of emitting plasma produced in the HCP device was imaged with a lens  $L_1$  onto the plane of an iris I. The image was spatially defined by the iris I to the area of the 1-mm slit of a  $\frac{1}{2}\text{-m}$  spectrometer set for recording the spectrum on Kodak 101 film in the range  $\lambda$  200-350 nm. To monitor temporal variation of the uv intensity simultaneously, a small fraction of the beam was diverted by a mirror M to a photomultiplier-oscilloscope system placed behind a  $280 \pm 1 \text{ nm}$  interference filter.

Absolute spectral intensities were determined by comparative measurements of microdensitometer traces of the plasma uv spectra with those of standard carbon arc spectra. The carbon arc spectra were obtained by placing the real image of the standard carbon arc at the same point as the plasma which is to be compared. The identical optical path was used for both the plasma and the arc radiations, and the spectra were also recorded on the same film to minimize the sources of measurement error. The irradiation

tion time of the carbon arc was controlled by the shutter S.

The HCP device was filled with deuterium, xenon, and krypton gases at varying pressures below 1.3 kPa. The data used for comparison were taken from the shots with their optimum pressures for maximum compression in the pinch. Figure 3 shows the typical oscilloscope traces of a uv ( $\lambda 280$  nm) signal monitored with the photomultiplier together with the voltage signal of the center electrode. The uv signal shows a sharp spike with a fast rise time of 100 ns followed by a long tail lasting for 5  $\mu$ s. The fast rise time is due to the fast collapse of the current sheets toward the axis of the HCP, and the long tail is due to a long confinement of the plasma in the center hole. The pulse width of the first spike is approximately 1  $\mu$ s full width at half maximum (FWHM).

Figure 4 shows an example of uv spectra recorded on film and their microdensitometer readings in the range from  $\lambda 200$  to 350 nm. The spectrum (Hg) of a mercury lamp for wavelength calibration and three spectra (C) of carbon obtained with five, one, and one-fifth second exposure times for absolute intensity references were also recorded on the same film. The film densities for uv emission below  $\lambda 260$  nm are too low for measurement due to poor sensitivity of the film in this range. The spectral radiant energy of the plasma is obtained by finding an exposure time  $t_p$  of the carbon arc emission that gives a film density equal to that obtained from the plasma spectrum at a given wavelength.

The spectral radiant energy  $J$  is

$$J = W^c t_p, \text{ J m}^{-2} \text{ nm}^{-1}$$

where  $W^c$  is the spectral radiant emittance of the carbon arc. The average spectral radiant emittance  $W$  of the plasma is

$$W = J / t_e, \text{ W m}^{-2} \text{ nm}^{-1}$$

where  $t_e$  is the period of the uv emission from the plasma. Although the actual uv emission signal shows a 1- $\mu$ s spike with a 5- $\mu$ s tail, an equivalent emission time of 2  $\mu$ s is used for  $t_e$ , to obtain an average emittance during the uv spike.

The results for Xe plasma are shown in Figure 5. The solid circles represent the measurements. The curve with lower values is a blackbody emittance at a temperature of 13,600 K at which the most efficient (10.8%) emission can be expected for the iodine laser pump band. The emittance of the plasma is approximately two orders of magnitude stronger than that of the ideal blackbody. This result is due to the fact that the plasma in the HCP is produced at a higher temperature, the emission characteristics also do not follow the Planck's law, and dense and broadened lines tend to raise the continuum emission. These features are advantageous for broad-band pumping of lasers, such as an iodine laser, Table 1 shows the emittances of different gases tested. In the table xenon or xenon-doped deuterium shows the highest emittance in the uv range. This result is expected for the high atomic number ( $Z = 54$ ) of xenon since both bremsstrahlung and line emission strongly depend on  $Z$ . However, it may also be due to improved plasma-focus formation

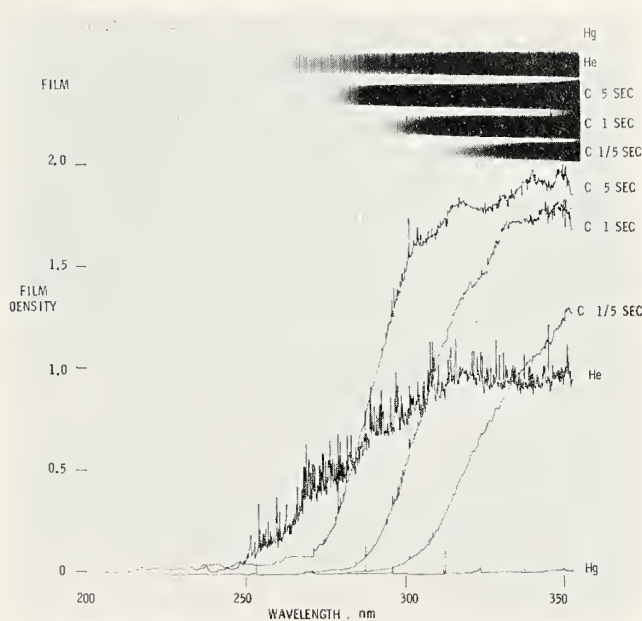


FIG. 4—Spectra of the He plasma and C arc.

with xenon as evidenced on the voltage signal monitored.

### Discussion

The spectral emittance can be integrated to obtain the total radiant power

$$P = \int_{\lambda} \int_s W_{\lambda} d\lambda ds$$

where  $s$  is the surface area of the plasma volume. For the iodine laser pump band,  $\lambda = 250$ – $290$  nm, the total radiant power may be approximated by

$$P = \langle W \rangle S \cdot \Delta\lambda$$

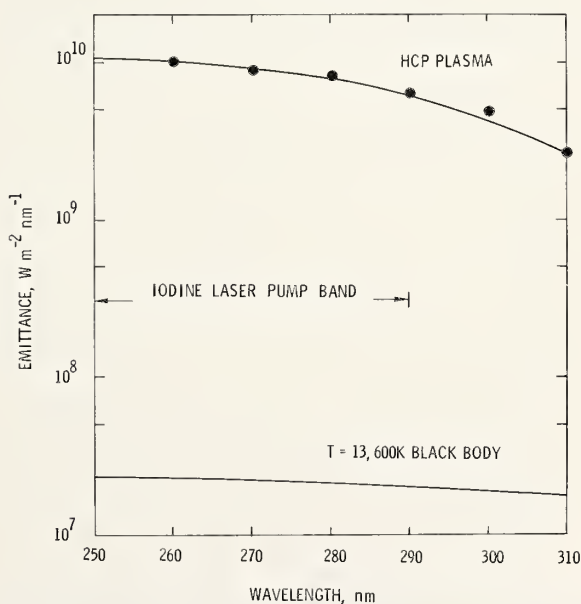


FIG. 5—Spectral radiant emittance of Xe plasma compared with that of a blackbody at 13,600 K.



TABLE 1  
Emittance of Different Gases,  $10^9 \text{ W m}^{-2} \text{ nm}^{-1}$

Type of Gas	Wavelength, nm					
	260	270	280	290	300	310
Xenon	10.03	8.90	8.39	6.33	5.15	2.50
Deuterium	6.02	5.34	3.60	2.38	1.75	0.94
Helium	4.35	4.45	3.60	2.77	1.55	1.25
D <sub>2</sub> (Xe)	10.03	8.90	6.59	4.02	1.87	0.99

where

$$\langle W \rangle = \frac{1}{\Delta\lambda} \int_{\lambda_0 - \Delta\lambda/2}^{\lambda_0 + \Delta\lambda/2} W_\lambda d\lambda$$

assuming isotropic radiant power over the total plasma surface  $S$ . For a pair of plasma foci of 5-mm diameter and 10-mm length each,

$$S = 2 \times \pi \times 5 \times 10^{-3} \times 10^{-2} \text{ m}^2 = 3.14 \times 10^{-4} \text{ m}^2$$

using an average emittance  $\langle W \rangle$  for the xenon plasma,

$$\langle W \rangle = 8.9 \times 10^9 \text{ W m}^{-2} \text{ nm}^{-1}, \text{ and } \Delta\lambda = 40 \text{ nm}.$$

Therefore,

$$P = 111.8 \times 10^6 \text{ W}$$

The total radiant energy  $U$  is then

$$U = P\Delta t$$

where  $t = 2 \mu\text{s}$  is the duration of the emission, thus,

$$\begin{aligned} U &= 112 \text{ MW} \times 2 \mu\text{s} \\ &= 224 \text{ J} \end{aligned}$$

This corresponds to an efficiency of 0.8 percent against the input energy of 27 kJ. This rather low efficiency is mainly due to the mismatch between the impedances of the external circuit and the HCP device. The HCP device has extremely low inductance of 4 nH and necessitates a fast capacitor bank for the maximum power input to the device. The external circuit used had an inductance of approximately 35 nH with a ringing period of 14  $\mu\text{sec}$ , resulting in a large mismatch of the impedance on the pinch device. The efficiency may be further improved by adopting a crowbar circuit (that is, circuitry that prevents subsequent oscillations after the peak current is developed) to avoid the ringing of the circuit and to extend the emission time. We expect an improvement of efficiency up to a few percent by adopting a fast bank and a crowbarred circuit. This value is comparable to the 4.5 percent efficiency achievable with the conventional xenon flashlamps.

The uv spectrum of the HCP plasma shown earlier contrasts strongly with that of a conventional flashlamp. While the flashlamp spectrum shows a sharp decrease below  $\lambda 300 \text{ nm}$ , the plasma spectrum shows increasing emittance toward the shorter wavelength

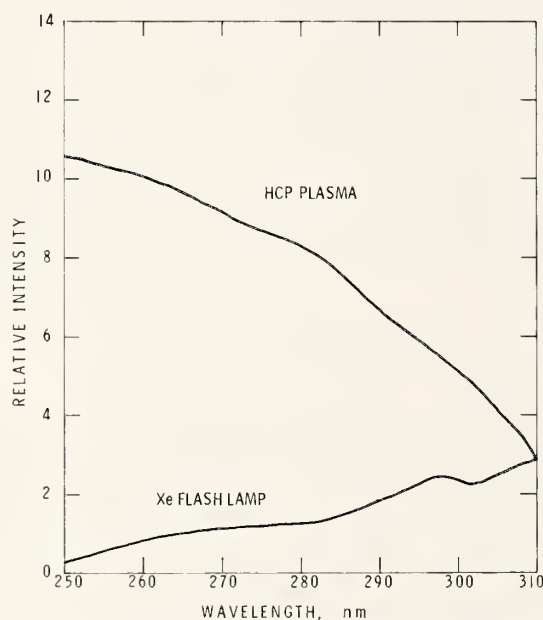


FIG. 6—Comparison of shapes of spectra. The HCP plasma spectrum shows increasing intensities for shorter wavelengths, while the flashlamp spectrum has a steep fall toward the short wavelength range. The two spectra are normalized at  $\lambda = 310 \text{ nm}$ .

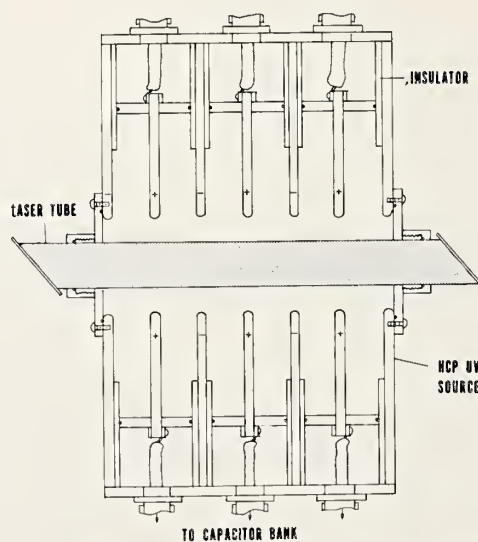


FIG. 7—Multiple array for transverse pumping of a laser cavity placed on the axis of the HCP. A number of plasma rings are expected to surround the laser cavity to result in an efficient coupling of uv source with the lasant.

range (Figure 6). This is due to the fact that the HCP electrons enhance the emission in the shorter wavelength ranges. Therefore, the HCP plasma is not only a near-uv source, but the emission extends to the vacuum uv range where the flashlamps have negligible emittance. Intense vacuum uv sources become progressively important as vacuum uv pumped lasers are now being developed and research on photochemistry in the uv range is extended further.

The HCP device also offers an important advantage over the flashlamp in the output power level. In contrast to the conventional sources, the HCP device does not share the limitations of the output power level because the plasma in the HCP is confined by strong magnetic fields which prevent the plasma from contacting the walls of the device. Therefore a substantially higher power output can be obtained by increasing the input power without severely shortening the useful life of the source. For example, a xenon flashlamp with 40 MW uv output only lasts for several shots at best, while the small prototype HCP device tested here has virtually no limitation on its lifetime with the uv output exceeding 100 MW.

The uv emission measured in this experiment was from the HCP device without optimization for uv production. For iodine laser pumping, the plasma temperature may be too high when compared to the optimum temperature of 1.2 eV. To obtain plasmas at a lower temperature the filling pressure may be increased and metallic dopants such as cadmium or zinc may be added. In fact, any desired uv range can be obtained by choosing suitable operating parameters. This freedom is not available with the conventional sources.

There is a possibility that a multiple array of HCP units may be used to pump a laser cavity transversely, as shown in Figure 7. The cylindrical laser cavity is placed along the axis of the device so that uv radiation from the surrounding plasmas could be used most effectively. Future experiments with this arrangement will be used to test the feasibility of increasing the power level of the iodine laser where the laser power at present is flashlamp limited.

### Summary

UV emission from hypocycloidal-pinch plasmas in different gases was measured. The radiant power of 100 MW is available for the iodine laser pump band. The advantages of the plasma uv source over the conventional flashlamps are recognized in output power level, spectral range, and useful lifetime of the device. In addition, construction of a multiple array of the hypocycloidal pinches for transverse pumping of a laser may be possible.

### Acknowledgments

The authors are grateful to Dr. F. Hohl for his continuous interest and support of the experiment. Also, the experiment has greatly benefited from the technical assistance of C. B. Apple. This work is supported in part by NASA Grant NSG 1235.

### Literature Cited.

- Beverly III, R. E.; Barnes, R. H.; Moeller, C. E. and Wong, M. C. (1977): Ultraviolet Spectral Efficiencies of Surface-Spark Discharges with Emphasis on the Iodine Photodissociation Laser Pumpband. *Appl. Opt.* **16**, 1572.
- Borovick, B. L.; Zuev, V. S.; Startsev, A. V and Shirokikh, A. P. (1975): Electrical Brightness, and Gasdynamic Characteristics of High-Current Discharges in Nitrogen and Argon at Pressures of 1–11 atm. *Sov. J. Quant. Electron.* **4**, 1268.
- Filippov, N. V.; Filippova, T. I. and Vinogradov, V. P.; (1962): Dense, High-Temperature Plasma in a Noncylindrical z-Pinch Compression. CN-10/226, Nuclear Fusion, 1962 Supplement Pt. 2, p. 577.
- Gusinow, M. A. (1975): Spectral Enhancement of Near UV Xenon Flashlamps. *Appl. Optics* **14**, 2645.
- Lee, Ja H. and Williams, M. D. (1977): UV Emission from a Metal Plasma in a Plasma-Focus Apparatus. *Bull. Am. Phys. Soc.* **22**, 1211.
- Lee, Ja H.; McFarland, D. R. and Hohl, F. (1977): Production of Dense Plasma in a Hypocycloidal-Pinch Apparatus. *Phys. Fluids* **20**, 313.



# Xanthic Creek Chub, *Semotilus atromaculatus*, from West Virginia

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Photo Not  
Available

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### Introduction

Three xanthic specimens of the creek chub, *Semotilus atromaculatus*, were collected in April 1976 from a farm pond, tributary to Glady Fork, Monongahela River drainage in Randolph County, West Virginia (latitude 38° 50', longitude 79° 42' 30"). They were taken by seine from a school of several hundred creek chub, along with 84 typical specimens. The pond consisted of 2.4 ha of open water, was 6 m in depth and had one small tributary. The bottom was mud with no obvious vegetation. Brook trout, *Salvelinus fontinalis* and rainbow trout, *Salmo gairdneri*, were stocked in the pond. Creek chubs may have entered via the tributary or been introduced with the trout. No creek chub was seen in the tributary for 50 m upstream.

The xanthic specimens were readily visible among the typical creek chub from a distance of 20 m. When first captured, they were kept alive, photographed, then preserved in 10 percent formalin. Additional photographs of recently killed typical and xanthic specimens were taken. The live and freshly killed xanthic specimens were essentially the same in size and chromatophore pattern to the typical creek chub. The striking difference was the distinctly orange chromatophores where melanophores are normally found. The spot in the dorsal fin was decidedly orange, the dorsal half of the body and head light orange, and the caudal fin a light orange. The eyes appeared normal, and a few scattered micromelanophores could be seen along the lateral band and at the caudal base on one specimen.

### Methods and Results

After transfer from formalin to 40 percent isopropanol, the color of the xanthic specimens faded as occurs with xanthophils and carotinoids in alcohol (Fugii, 1969, and personal experience). In a few days they appeared opaque white and without chromatophores. In contrast, the typical specimens continued to possess a melanophore pattern characteristic of the species. The following description was made from the preserved specimens (Figure 1): melanophores were absent from all fins on the xanthic form. Under 10X magnifications, scattered micromelanophores were visible along the lateral band (faintly visible with the naked eye) and widely scattered micromelanophores were present on the dorsal half of the body and upper lip. There was no pattern to the micromelanophores on scales or elsewhere and no intermyomere lines. Typical specimens (viewed with the naked eye) had a distinct lateral band, dark spot in the anterior base of the dorsal fin, dark upper body, black upper lip and chin, and diagonal intermyomere lines above the lateral band. Under 10X magnifications, micromelanophores were visible along the rays of the dorsal, anal and caudal fins.

Several measurements (standard length, head length, body depth, predorsal length and preanal length) and counts (lateral line scales, scales above the lateral line, scales below the lateral line, and anal rays) following Hubbs and Lagler (1958) were made on the xanthic and 10 typical specimens. The xanthic specimens (49.0 to 50.7 mm s.l.) were similar in



FIG. 1—Xanthic specimen (top) and normally colored specimen (bottom) of the creek chub, *Semotilus atromaculatus*, after preservation and loss of orange pigment in alcohol.

morphometrics and meristics to the normal specimens. All (xanthic and typical) were of the I<sup>+</sup> age group and ranged from 40.0 to 80.0 mm s.l.

### Conclusions

Xanthic freshwater fishes from the natural waters of the United States are rare. Dawson (1964, 1966, 1971) lists many occurrences of albinism, but only one freshwater xanthic reference: Allen and Neil (1953) who reported a xanthic largemouth bass, *Micropterus salmoides*. Denoncourt, Robbins and Stauffer (1976) reported seven xanthic specimens of tessellated darter, *Etheostoma olmstedii*. Xanthic trout are common in hatcheries and rearing ponds in many states. However, this distinctly orange form, similar to some "golden" trout, had not been described for any freshwater minnow. They are believed the result of genetic variation similar to that found in "golden" and "blue" trout. Gordon (1957) demonstrated the occurrence of golden coloration in the guppy, *Lebistes reticulatus*, as being a recessive mutant trait which reduced melanophore characteristics by 50 percent. Mating a golden specimen with a wild type resulted in F<sub>1</sub> offspring colored like the wild parent. Sibling (F<sub>1</sub>) crosses produced a wild to golden ratio of 3:1, as expected for simple Mendelian recessive traits. Sibling (F<sub>1</sub>) crosses of offspring from wild x albino stock, yielded a wild to albino ratio of 53:1, indicating that albinism is a recessive, semilethal mutation. Survival of this xanthic or "golden" strain in the creek chub and possible increase in numbers of the xanthic forms remains to be investigated.

All specimens have been cataloged into the Appalachian Environmental Laboratory Museum, University of Maryland, at Frostburg State College, Frostburg, Maryland (AEL 61).

*Addendum*—Additional specimens were observed in summer 1977.

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#### Literature Cited

- Allen, E. R. and Neill, W. T. (1953): A Xanthic Largemouth Bass (*Micropterus*) from Florida. *Copeia*. (2), 116-117.
- Denoncourt, R. F., Robbins, T. W. and Stauffer, Jr., J. R. (1976): A Description of Xanthic Tessellated Darters, *Etheostoma olmstedi* (Teleostei: Percidae). *Copeia*. 1976(4), 813-815.
- Dawson, C. E. (1964): A Bibliography of Anomalies of Fishes. Gulf Res. Rept. 1, 308-399.
- Dawson, C. E. (1966): A Bibliography of Anomalies of Fishes. Supplement 1. Gulf Res. Rept. 2, 169-176.
- Dawson, C. E. (1971): A Bibliography of Anomalies of Fishes. Supplement 2. Gulf Res. Rept. 3, 215-239.
- Fugii, R. (1969): Chromatophores and Pigment. In Fish Physiology (W. S. Hoar and D. J. Randall, eds.), Vol. 3, pp. 307-353, Academic Press, N. Y.
- Gordon, M. (1957): Physiological Genetics of Fishes. In The Physiology of Fishes (M. E. Brown, ed.) Vol. 2, pp. 431-501, Academic Press, N. Y.
- Hubbs, C. L. and Lagler, K. F. (1958): Fishes of the Great Lakes Region. Cranbrook Inst. Sci. 26 (2nd ed.), 213 pp.

# Sublethal Thermal Shock Effects on Predation Susceptibility of Fathead Minnows

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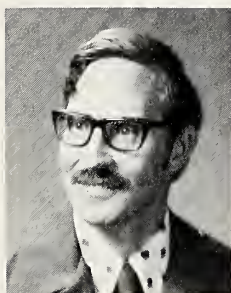
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may suffer lethal thermal shock (Hagen, 1972). Thermal shock which does not cause immediate lethality still may affect behavior, predator-prey relations, metabolic efficiency, food-chain relationships, community structure, and natural selection (Coutant, 1970; Hagen, 1972).

The interactive effect of thermal shock on predator-prey relations is one potentially important area that has been little researched. Although we tend to think of the temperature exposure of individual fish as quite limited, most predators follow rhythmic cycles of movement and feeding that expose them to a range of temperatures. Consequently, prey organisms may be forced into similar rhythms of temperature exposure during predator avoidance as they seek refuge in shallow water or at the water surface where heated water tends to concentrate (North and Adams, 1969). In lakes and reservoirs receiving heated water, the range of temperatures encountered by both predator and prey potentially become even greater than in natural waters.

The objective of this study was to investigate changes in the susceptibility of prey species to predation after recurring thermal stress, and to evaluate changes in behavior or signal responses (Hagen, 1972).

## Materials and Methods

Prior to beginning experiments on the effects of thermal shock on prey's predator avoidance, an upper thermal maximum for fathead minnows (*Pimephales promelas*), acclimated at 18° C, was determined by placing fish (10 fish per temperature) in water at 1-degree temperature intervals from 26° C to 35° C. Predator-prey experiments were begun by acclimating prey organisms (*Pimephales promelas*) to the holding tank (18° C) for at least 14 days and to the observation tank (18° C) for 3 days. Predators (1-3 *M. salmoides*; 15- to 20-cm total length) were acclimated (18° C) to the experimental tanks (112 × 47 × 47 cm) for at least 17 days prior to experimentation. Predators were starved for seven days prior to

**Abstract**—Fathead minnows (*Pimephales promelas*) acclimated at 18° C in a laboratory holding tank were exposed to 32° C for 85 minutes twice daily for 6.5 days. No significant differences in activity or avoidance of largemouth bass (*Micropterus salmoides*) were found between control and test fish. Apparently, the minnows became acclimated to the recurring thermal stress. If this hypothesis is correct, the establishment of thermal standards based on thermal resistance after laboratory acclimation of test fish to a single temperature does not accurately reflect the natural thermal capabilities of this species.

## Introduction

Steam-electric power plants supply most of the electric power in the United States (Levin et al., 1972). These plants require large quantities of water for condenser cooling, and generally return it directly to the receiving water. Fish exposed to rapid temperature change, with little or no time for acclimation,



TABLE 1

Number of stressed and unstressed fathead minnows eaten by largemouth bass in predation tests.

Test No. and No. of fish per run	No. fish eaten per run		
	Control	Stressed	Totals
I			
30	7	6	13
30	5	7	12
II			
20	2	2	4
20	2	2	4
III			
16	0	2	2
16	4	4	8
IV			
16	3	0	3
16	2	3	5
V			
40	8	12	20
12	2	2	4
Totals	35	40	75

predation tests. Photoperiods were maintained (12 hours light, 12 hours dark) for all fish.

Two groups of equal numbers of minnows were randomly selected from the holding tank for each experiment. Control and treatment fish were marked by removing the pelvic fin on opposite sides of the body. Treatment fish were subjected to periods in 32° C water twice daily (stress beginning at 0700 and 1600 hours, respectively) and once on the morning of the seventh day. The fish were exposed to 32° C water for 85 minutes, then gradually returned to water at 18° C. Water temperatures were maintained by an overflow water exchange system coupled with a thermostat-regulator to cold and hot water sources. Transition from test to acclimation temperature took about 20 minutes. Bass were never subjected to thermal stress.

Predation tests immediately followed the morning stressing period on the seventh day. Groups of prey composed of 50 percent stressed/50 percent control fish were placed in each predation tank. The test was terminated when the bass had consumed about 50 percent of the minnows, or after elapse of 2 hours. The remaining minnows were removed from the tank, and the numbers of surviving stressed and control fish were recorded.

Results of the predation tests were statistically analyzed by a modification of Cochran's Q test for related observations with replication and unequal sample size. This test was used instead of a signed ranks test because of the large proportion of zeros, ties, and the noncontinuous nature of the data.

Subjective observations of behavior (activity level and amount of straying from the school) were made during the first 6 days of stressing at 15 fixed, 10-minute intervals each day and the observations averaged. The Cox and Stuart test for trends (Conover,

1971) was used to analyze data from these periodic observations.

## Results and Discussion

Most prey fish acclimated to 18° C died when exposed to temperatures 33° C and above. At 32° C fish lost buoyancy and equilibrium and swam erratically but did not die. Therefore, we determined that the critical thermal maximum for fathead minnows acclimated at 18° C was between these two temperatures and selected 32° C as the sublethal temperature to be used in our predation test.

Exposure of minnows to 32° C yielded no significant ( $\alpha = 0.50$ ) differences in the ability of stressed and unstressed minnows to avoid predation by LM bass (Table 1). This result contrasts with observations of Coutant (1973) who reported increased susceptibility of juvenile salmon to predation after a single thermal stress. Eurythermal species (such as fathead minnows) may recover more quickly from sublethal thermal stress than do stenothermal species (such as salmonids). Another explanation could be that the predation tank was so small that prey could not avoid the predators. Since some individual minnows repeatedly succeeded in avoiding the predator and since in no experiment were all prey consumed, this explanation does not seem to support the data. Perhaps, the most plausible explanation is that a recurring stress may result in acclimation and an increased CTM as was reported by Otto (1974). If the latter hypothesis is true, neither group of fish was thermally stressed prior to the predation tests even though one group was subjected to a temperature causing severe stress for fish acclimated to 18° C. If this explanation proves correct in subsequent experimentation, the fishes' ability to acclimate to a recurring stress may need to be considered in the setting of thermal standards.

There were absolute but nonsignificant differences ( $\alpha = 0.05$ ) in average activity levels and the number of fish straying from the school ( $\alpha = 0.20$  for unstressed and  $\alpha = 0.50$  for stressed) between stressed and control groups. Lack of significant effects on activity and straying differs from the results of previous authors for other species (Olla and Studholme, 1971). However, these data support our hypothesis of progressive acclimation to the stress with continued exposure.

## Acknowledgments

The modifications of Cochran's test were developed by Dr. Walter Pirie of the Virginia Polytechnic Institute and State University's Statistics Department. The Virginia Cooperative Fishery Research Unit and the Virginia Polytechnic Institute and State University supplied space, material, and financial support. Oklahoma State University paid publication costs.

## Literature Cited

- Conover, W. J. (1971): Practical Nonparametric Statistics, p. 462. Wiley, New York.  
Coutant, C. C. (1970): Thermal Pollution-Biological Effects—a

- Review of the Literature of 1969, pp. 90. Battelle Memorial Inst., BNWL-SA-3255.
- Coutant, C. C. (1973): Effect of Thermal Shock on Vulnerability of Juvenile Salmonids to Predation. *J. Fish. Res. Board Can.* **30**, 965-973.
- Hagen, H. K. (1972): Fish Behavior Related to Thermal Pollution. *Proc. Inst. River Mech., Colorado State U., Fort Collins* **2**, 11.1-11.23.
- Levin, A. A., Birch, T. J., Hillman, R. E. and Raines, G. E. (1972): Thermal Discharges—Ecological Effects. *Environ. Sci. Tech.* **6**, 224-229.
- North, W. J., and Adams, J. R. (1969): The Status of Thermal Discharges on the Pacific Coast. *Chesapeake Sci.* **10**, 139-144.
- Olla, B. B., and Studholme, A. L. (1971): The Effects of Temperature on the Activity of Bluefish, *Pomatomus saltatrix* L. *Biol. Bull. (Woods Hole)* **141**, 337-349.
- Otto, R. G. (1974): The Effects of Cyclic Thermal Regimes on Heat Tolerance of the Western Mosquitofish. *Trans. Am. Fish. Soc.* **103**, 331-335.



## Accountability for Research in Agriculture\*

James R. Nichols

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James R. Nichols, dean and former executive vice president of Select Sires, Inc., Columbus Ohio, received B.S. (1949) University of Tennessee, and M.S. (1955) and Ph.D. (1957) University of Minnesota. He was honored as the 1975 Man of the Year in Service to Virginia Agriculture and is Director of the Virginia Agricultural Experiment Station. He is an agricultural consultant in the U.S. and abroad, and was an early advocate for a College of Veterinary Medicine at VPI&SU.

sirable and inevitable. What follows will be restricted to accountability for agricultural research within a land-grant college system although much should apply to any institution.

### The Individual

All accountability must start with the individual. He is the one who best understands his own motivation, his capabilities, and his limitations. He can evaluate his professional progress, his contributions to his scientific discipline and to the college or departmental goals. *The scientist must first be satisfied with himself.* Many scientists believe that this is where all accountability should begin and end. But, while the scientist must first be accountable to himself, he must also be accountable to his peers. Furthermore, his research goal and effort should mesh, not compete, with the college or departmental goals.

### The Department

The department is the basic unit for effective operation within the land-grant university system. It is the focal point where the individual scientist's projects are conceived, formulated, and implemented. Accountability must extend beyond the individual scientist to include the department. Is the research project compatible with the departmental goals? In multidisciplinary research, can the concept of accountability be properly apportioned among the several individuals listed as collaborators? These are questions which require use of the departmental unit as the step-stone for accountability. The department head is usually an advocate for his faculty and for their research. He must also be accountable for their research. Is it well conceived and managed? Are the prospects for successful completion and useful results such that he can defend the work?

Does the question of whether the research is basic or applied affect the need for accountability? Some say basic research cannot be structured for predictable results and should not carry any burden of proof regarding its worth. The distinction between basic and applied research is hazy at best, and both may yield valuable, practical returns, or nothing of known value at the time.

Being accountable for one's actions is a measure of the maturity of an individual or of a group. Both-ersome as it may seem to each of us at times, accountability is an inescapable necessity. Society holds all citizens accountable for their actions through a legal system which attempts to guarantee individual rights without penalty to the national social structure.

Studies show that the public is the principal beneficiary of agricultural research. Because it is in the public interest, agricultural research has been financed mostly with tax funds. Thus, it is essential that such monies be scrupulously accounted for. We must be prepared to show that the funds are not misused, nor wastefully squandered, and that there is, and will be, substantial economic or social returns (benefits) from such an investment. Without this kind of accountability, continuing financial support for agricultural research would diminish. The land-grant college system would fail to fulfill its mission, and an increase in per capita cost for food and fiber would result.

Research accountability, within reason, is both de-

\* Based on the keynote address to the Agriculture Section at the Academy's annual meeting held on May 11, 1978, in Blacksburg, Virginia.

Regardless of whether the work is considered basic or applied, accountability is expected when public funds are spent to support a study.

In discussing the differences between basic and applied research, Arndt and Ruttan said: "Applied agricultural research may be understood as a search for *new technology within the limits of existing scientific knowledge*. Basic knowledge established the *boundaries* within which innovation is possible. If basic knowledge is static, applied research is subject to diminishing returns and will eventually come to a halt as the costs of successive technical innovations within the existing knowledge boundary rise. Without an increase in *basic knowledge*, technical change will eventually stagnate as the marginal cost of innovations rises to meet marginal returns."

Advances in basic knowledge extend the potential frontiers of applied research and make it more productive by providing new opportunities for technical innovations. Thus, the faster the advance of basic knowledge, the greater can be the productivity of applied research. The rate of technical progress, then, reflects both the rate of growth of new knowledge (resulting from investment in basic or supporting research), and the rate of technical change as reflected by adaptation of new procedures in agricultural production of food and fiber and in channels for processing and marketing of that food and fiber.

New information, basic knowledge, does not flow from research at a steady rate, any more than a small stream in the Virginia forests maintains a constant flow. Rather, it comes erratically and sometimes spontaneously, but more often after long, diligent periods of frustrating and exhausting effort. Therefore, agricultural efficiency, through applied research productivity, progresses by spurts reflecting those periods of "feast or famine" within basic research projects. Those calling for greater accountability from scientists must recognize these expected variants in progress.

### Evaluation

Peer judgment of quality may be the best criterion of research performance. Here, the department head plays an important role through appropriate peer review procedures. If properly done with objectivity and honesty, this process should yield the strongest possible recommendations for professional recognition and academic reward in the granting of tenure, promotions, and salary increases.

The evaluation of organized research programs is usually first conducted at the departmental level by peers. Here, adjustments can be made for improvements. If changes are warranted but not made by the departments involved, accountability and creditability of the entire group will suffer. The accountability of the individual scientist may well reach its peak of significance at this level; each being responsible to his peers for providing the greatest possible contribution toward reaching the potential strength of the total departmental program. Should an individual not provide his full share, adjustments toward that goal must be made.

### College

The college is the next level of administrative organization requiring accountability. It follows naturally and logically from consideration of the individual and the department. For an optimum flow of new knowledge to come from the college would require the combined efforts of individual scientists working together within their departments, and cooperating freely on multidisciplinary projects. The performance of the college is judged by the public as the combined efforts of all departments, often with little notice of the individual or department.

For optimum performance, cooperation among scientists is essential, regardless of departmental or disciplinary affiliation. Organizational structures can enhance this but cannot guarantee it.

The new Animal Sciences building at VPI&SU represents an effort to assemble personnel by certain common interests while preserving departmental identity. Those concerned with livestock, dairy, or poultry will be housed together as a commodity-oriented group. They will be housed in close proximity by disciplines (physiology, genetics, nutrition, etc.). The cross-pollination of thought and effort occurring from these daily contacts among scientists should improve the quality of research. Accountability will also be enhanced by improvements in efficiency in the use of similar equipment and facilities.

Much research today involves multidisciplinary commodity approaches. In the College of Agriculture and Life Sciences at VPI&SU, the goal is to develop an atmosphere whereby a free and easy, almost casual, crossing of disciplinary lines can occur, and cooperation among departments and scientists can result more readily.

### Legislature

Food and agriculture are increasingly a part of the political process in this country. Current trends point to more federal government decisions affecting agriculture, particularly in research. Sometimes important decisions directly affecting agricultural research are made by persons without adequate information and expertise. This is regrettable as it may impose artificial constraints upon the research activity and reduce the effectiveness of that research. This, in turn, makes the task of accountability more difficult—for the individual, the department, and the college. The resultant misunderstandings may pose additional roadblocks toward funding. We have a responsibility to provide governmental agencies, legislators, and the general public with basic scientific facts which should lead to objective policy decisions by government instead of responses to narrow group interests.

Agricultural research has been financed with public tax monies for many years in this country. It is the primary source of dollars for research in the land-grant system. It is in the public interest that this should continue because these gains from research will benefit the public. Returns to consumers come through increased food supplies, improved food quality, convenience and safety, and in reasonable



prices. Exports of agricultural products are important in balancing the U.S. payments abroad. Improved labor efficiency, resulting from agricultural research, releases labor which can be used by other industries to permit production of those items that provide the high standard of living we have come to enjoy. Likewise, the scientist utilizing these dollars must provide government officials with the justifications they need. Thus, we must have an accountability to those agencies of the state and Federal governments which supervise the spending of such funds.

### Industry

For effective agricultural development, it is essential that farmers, food processors, and agribusinesses make use of these new technological advances made possible by agricultural research. It is the responsibility of scientists to develop new basic knowledge—thus enlarging the boundaries within which technical change can be made. It is their further responsibility to develop some of the methods whereby indicated potential adjustments to agricultural production techniques may be implemented. Following a period of reduced agricultural research, we are entering an era in which the pantry, storing unused fundamental knowledge, is about as empty as Mother Hubbard's cupboard. We must place increased emphasis upon basic research to assure that the *pantry shelves* of knowledge will not soon be bare. At the same time, there must be applied agricultural research which provides farmers with practical solutions to today's problems. Agricultural Extension Services provide an excellent mechanism to demonstrate accountability of the research scientist to those producers.

### Consumers

Consumers have the most to gain from agricultural research. They are the receivers of the economic benefits, reduced food costs, and quality that flow from good research. The urban consumer, and not the rural consumer, receives the true ultimate benefits from agricultural research. This story must be effectively told. It has not been up to this point. In this fashion, questions about the use of tax money for agricultural research may be answered.

### Conclusions

Accountability is inevitable, essential, and mostly justifiable. It moves in unending reversible order; from individual to department, to college, to university, to legislatures, to farmers and industries, and to the general public. The pathway for accountability, then, reverses itself and, hopefully, changes into creditability as it gains support along the way. Accountability should yield recognition for agricultural scientists. It should strengthen the support and not hinder productivity.

Increased emphasis on accountability is one of the most significant developments of the 1970's. Detailed, specific documentation of projected impacts of programs for which funds are being sought is now required. The increased accountability requirements imply less freedom for managers of public research and education. It requires larger portions of resources for studying the impact of the past and proposed programs and in providing reports on them. Justification will become a more dominant factor in administering and conducting research.

Agricultural scientists will benefit from the age of accountability. By comparison to most other public endeavors the record speaks for itself.

## FEATURES

### *Science and Society Notes*

#### PROTECTION FOR VIRGINIA'S FLORA

Virginia is a state blessed with an abundance of botanical speciation. Nevertheless, there is a significant number of plant species which are either threatened, endangered, or close to extinction.

Not all of these can even be listed, as the stability of many species has not been researched. An official, all encompassing document proclaiming which Virginia plants should be protected does not exist. True, the Smithsonian Institute did list various endangered, etc. Virginia flora in its bulletin serial No. 94A, *Report on the Endangered and Threatened Species of the United States*, but even a nouveau botanist could recognize the incompleteness of this list. In addition, Leonard J. Uttal of VPI prepared a list some years ago of similar plants. This document was prepared in conjunction with the Virginia Federation of Garden Clubs and is a compliment to his hard work, but again the issue of incompleteness arises.

No list exists which considers the entire spectrum of the plant kingdom. For example, there are many lower kingdom species which are not mentioned on any of the existing abbreviated lists. While perusing these lists, one might wonder why such plants as *Lycopodium complanatum* (ground pine, running cedar) are not listed, especially bearing in mind the statewide rape which occurs each year as unconcerned citizens collect their greenery for the yuletide season.

One might wonder why a protection list does not exist as a result of State legislation. Surely, the Commonwealth should have done something by now! But in a way it is really not difficult to see why they have not. Most state agencies that have the auspices do not have qualified personnel to implement such a task. In addition, our State government probably has not taken the lead because such action is very controversial and a dangerous path to tread; protection lists are inflationary for private enterprise. For example, if an endangered plant were found on a hillside where a factory was proposed, a protection list backed by legislation could prohibit the construction of the factory, and possibly cost the developer thousands of dollars to relocate to a less economically feasible location. Voting for approval of such protection list legislation rarely wins many corporate votes or secures large private funding to support election campaigns.

Nevertheless, there might be a solution. First, citizens must voice enough concern to get the idea started. As a result, State agencies such as the State parks or the Science Museum of Virginia would be encouraged or directed to sponsor a project to identify and list all plant species which are endangered. Funding through such sources as the Federal government or the Virginia Environmental Endowment could be secured to underwrite all expenses including salaries for taxonomists and research assistants. State colleges and universities could be enlisted to aid the research. Then conservation groups like the National Campers and Hikers Association, the Appalachian Trail Clubs, etc. could join the efforts to implement the final step, approval of legislation by the General Assembly to establish a protection list.

This would not be an easy task. It would involve an enormous amount of work just to research what species should be listed. Yet is this work not vitally important and urgently needed? How many species must we lose to the annals of extinction before something is done? Consider it—your support is desperately needed!

Richard S. Groover  
Park Director  
Maymont Foundation  
Richmond, Virginia

#### VIRGINIA FISHERIES: MANAGING A LIVING RESOURCE

A symposium on *Virginia Fisheries: Managing a Living Resource* was conducted by the Environmental Sciences Section at the 55th annual meeting of the Virginia Academy of Science on May 12, 1977 at the Virginia State College, Petersburg, Va. The symposium consisted of three panels and other presentations.

Mr. Cranston Morgan of the Shellfish Institute of North America began the program with welcoming and introductory remarks. He reminded the audience of the Commonwealth's lax philosophy on the use of sewage waters and adjacent lands; he then predicted that, in the next decade, Federal agencies would change their thrust from one of neutralizing sewage to one of stopping toxic and potentially toxic substances from entering Virginia's streams. Reasons for the increased sewage concern are the migration of



more retired persons from the colder and higher taxed areas of the country and an increased number of new industries. Dr. John Merriner of VIMS (Virginia Institute of Marine Science) followed Mr. Cranston with a description of *Virginia's Commercial and Recreational Fisheries*.

Dr. Jackson Davis of VIMS moderated the panel on *Options and Limitations in Fisheries Management*, which included the discussion of *Biological Considerations* by Dr. Ivar Strand (University of Maryland), and *Social and Cultural Considerations* by Dr. Michael Orbach (National Marine Fisheries Service).

The panel on *Current Management Agencies, Programs and Problems* was moderated by Mr. Robert G. Martin of the Sport Fishing Institute. The panelists were Dr. Alan Hoffman, Commissioner, Game and Inland Fisheries Commission on *Inland Fisheries*; Mr. James E. Douglas, Jr., Commissioner, Virginia Marine Resources Commission on *Estuarine Fisheries*; and Mr. Allen W. Haynie, a member of the Mid-Atlantic Fishery Management Council, on *Continental Shelf Fisheries*.

The third panel, with Mr. Cranston Morgan as its moderator, addressed itself to the *User Response*, and included panel members Mr. Vernon Drewer of H.V. Drewer & Sons, Mr. Gerald Schuder of Trout Unlimited, and Mr. James J. Nelson of Standard Products Company. Mr. Nelson discussed the inadequacy and inaccuracy of the data available for designing fishery management plans. He indicated that:

1. The original purpose of the reports and statistics of the fishery was to provide information. These same reports are now being used for the purpose of preparing management plans.
2. There is much marine biological and statistical information and very little socio-economic data; this produces an imbalance in opinions and conclusions in regards to management programs.
3. Privately owned fisheries, which outnumber publicly owned fisheries, are not required to release details of their operations to the public. Because of this, the Federal Government is not able to publish accurate information.
4. Standard Products Company has not been included in the selection, design, or interpretation of most research products for the NMFS or VIMS. Therefore, the industry has not had the opportunity to determine whether or not the reports in the data bank are proper to use in formulating management plans.
5. Operating a fishing business requires coordination of sales, management, finance, supervision and merchandising, and yet, on most councils, committees and boards, the industry member is in the minority.

The symposium ended with a lively open discussion and closing remarks on *Information Needs* by Dr. Jackson. In spite of simultaneously scheduled special seminar on Scientific Results from Project Viking cosponsored by almost all the other sections of the Academy, the Environmental Sciences Sectional Symposium attracted more than 60 participants.

Kuldip P. Chopra,

(Prepared from notes supplied by Cranston Morgan, Jr. and James J. Nelson)

## SYMPOSIUM HONORS JAMES JACOBS

The VAS section of Astronomy, Mathematics and Physics organized a symposium to honor *Dr. James A. Jacobs*, the retiring Professor and Chairperson of the Department of Physics at VPI & SU.

Jim Jacobs came to VPI in 1960 from the University of Iowa where he earned his B.S. (1937), M.S. (1940), Ph.D. (1941) and post-doctoral experience (1941-42). During his assistant professorship (1942-45), he directed the physics engineering development project and the multi-million dollar electron physics project funded by the National Research Defense Administration. This led to his direct promotion to the rank of Professor in 1945.

While he was Chairperson, the Physics Department at VPI experienced a dynamic growth. He is currently a member of the Executive Committee of the  $\phi\beta\kappa$  at VPI, and of the State Radiation Advisory Board.

Dr. John D. Wilson, Provost at VPI, welcomed the guests at the symposium chaired by Dr. Thomas E. Gilmer, Professor of Physics and Acting Dean of Arts and Sciences. Dr. Clifford Swartz of SUNY at Stonybrook and Editor of the *Physics Teacher* spoke on the *Royal Road to Panacea*. The topic of concern to Dr. Edward G. Taylor, Editor of the *American Journal of Physics* was *Whether Education Research Exists in Physics*.

A panel discussion on *New Teaching Methods vs. Old* included Max Dresden (SUNY at Stonybrook), Marvin Blecher (VPI & SU), D. Rae Carpenter, Jr. (VMI), L. David Roper (VPI & SU), James Trefil (U.VA.), and Hans von Baeyer (W & M). A social hour followed the panel discussion.

Dr. Alvin H. Bartlett of U. of Colorado and Editor of the American Association of Physics Teachers gave the banquet speech on *Physics Teachers and the Forgotten Fundamentals of the Energy Crisis*.

Vivian Welker  
Assistant Editor

## PSYCHOLOGY IN VIRGINIA

At the 1978 Virginia Academy of Science meeting in Blacksburg, the Psychology Section held a symposium on Psychology in Virginia, chaired by Professor Emeritus William M. Hinton, Washington and Lee University.

The participants and topics of their presentations were:

*Professor Frank Finger*, U. Va.: The History of Psychology Organizations in Virginia.

*Professor Richard Abidin*, U. Va.: The Virginia Board of Psychologists Examiners.

*Professor Robert Tipton*, VCU: The Virginia Psychological Association.

*Professor Frank Murray*, Randolph-Macon Women's College: Undergraduate Programs.

*Professor Paul Woods*, Hollins College: Master's Programs.

*Professor James Deese*, U. Va.: Ph.D. Programs.

*Professor Haller Gilmer*, VPI & SU: Where We Seem to Be Heading.

The current status of the undergraduate and graduate psychology programs in Virginia's college and universities are tabulated below.

In his paper on undergraduate programs, Frank Murray presented a summary of the curricula in psychology offered by 22 public and private institutions. The number of psychology courses offered ranged from a low of 9 courses, at one of the smallest private colleges, to 60 courses offered at the University of Virginia. Many of the courses offered at U. Va. were graduate level offerings. The minimum number of hours required in psychology for a major ranged from a low of 24 at Randolph-Macon Women's College to a high of 44 at Virginia Union.

All of the institutions responding to inquiries made by the VAS Psychology Section require their majors to complete a one- or a two-semester introductory, general psychology course, and over two-thirds of all the schools require both an experimental methods and statistics course, with the others requiring either a course in experimental psychology or in statistics. Half of the responding departments indicate that they offer courses in the area of experiential learning—some on-the-job training in related fields. There are 244 full- and part-time faculty employed by the 22 responding departments which range in faculty size from 3 to 40.

Paul Wood's paper on the master's programs revealed that the first master's programs in psychology began in 1921 at the University of Richmond and in 1928 at the University of Virginia. Virginia State and Virginia Commonwealth started their master's programs in the late forties. William and Mary and Hollins joined the master's program ranks in the 1950's. Between 1965 and 1976 the number of Virginia colleges and universities offering master's degrees in psychology doubled as Madison, Radford, VPI & SU, George Mason, Old Dominion University, and finally Norfolk State offered such programs. All but two institutions provide a general/experimental master's degree. In addition, some combination among more than 12 speciality areas are covered by 8 of the colleges or universities offering master's degrees. The specialties include social, developmental, animal/physiological, community/clinical, educational, counseling, school, industrial/organizational, applied behavioral science, and psychobiology.

The state's doctoral programs were reviewed in the paper presented by James Deese. Until the very recent establishment of a Ph.D. program at ODU and the Psy. D. by the consortium of Old Dominion University, Norfolk State, Eastern Virginia Medical School, and William and Mary, the state had only three institutions offering Ph.D.'s in psychology. The doctoral program at U. Va. was, from the early 1930's until 1970, almost entirely an experimental/physiological offering. With the introduction of the doctoral programs at VCU and VPI & SU, concentrations are now available for predoctoral training in clinical, developmental, community, industrial, organizational, social, counseling, animal behavior, hu-

## COUNCIL OF HIGHER EDUCATION REPORT

### Psychology Majors' Degrees Awarded, 1976-77

#### Public Institutions

Christopher Newport	35 B*	Radford	32 B; 27 M
George Mason	87 B; 35 M	U. Va.	175 B; 7 M; 7 D
James Madison	79 B; 15 M	V. C. U.	85 B; 30 M; 12 D
Longwood	9 B	V. P. I. & S. U.	93 B; 12 M; 4 D
Mary Washington	40 B	Va. St.	30 B; 3 M
Norfolk State	13 B	W. & M.	67 B; 4 M
Old Dominion	99 B; 10 M		

#### Private Institutions

Averett	6 B	Mary Baldwin	16 B
Bluefield	13 B	Randolph-Macon	22 B
Bridgewater	9 B	R-MWC	14 B
East. Mennonite	15 B	Roanoke	13 B
Emory and Henry	10 B	Sweet Briar	8 B
Hampden-Sydney	23 B	U. of Rich.	40 B; 9 M
Hampton Institute	27 B	Va. Union	9 B
Hollins	30 B; 10 M	Va. Wesleyan	8 B
Liberty Baptist	12 B	W. & L.	14 B
Lynchburg	12 B		

Totals:	Public	844 B	143 M	23 D
	Private	301 B	19 M	00 D
		1145	162	23

\* B = Bachelors

M = Masters

D = Doctorates



man information processing, psychobiology, and applied behavioral science.

As can be seen from the foregoing, Virginia institutions have in the last decade been experiencing rapid growth in numbers of students enrolled and numbers of programs offered at both undergraduate and graduate levels in psychology.

The Psychology Section of the Virginia Academy of Science, in cooperation with the psychology departments of all the Virginia's accredited institutions of higher education, is currently engaged in a state-wide survey of all psychology graduates of the class of 1978 to determine their subsequent education and occupational experience. A report on the survey results is planned at the Section's session during the 1979 Annual Meeting of the Academy.

William M. Hinton  
Washington and Lee University

Frank S. Murray  
and

Frederick B. Rowe  
Randolph-Macon Women's College



## APPOINTMENTS

### KIZER REPLACES JACKSON AS BUSINESS MANAGER

Franklin D. Kizer replaced Auzville Jackson as Business Manager of the VJS in July 1978.

At the February 4, 1978 meeting of the Ad Hoc committee on the Long Range Planning for the Virginia Journal of Science, Dr. Jackson had indicated his desire to be relieved of the managerial responsibilities, effective on October 1, 1978. His announcement came soon after Kuldip Chopra, Editor of the VJS, informed the Committee that the VJS would be back on its regular schedule with publication of the Spring 1978 issue, and that it was high time to pay serious attention to the business and financing aspects of the Journal's operation.

Dr. Jackson is the Chief Patent Counsel and Assistant Vice-President for Technology with Robertshaw Controls Company. With extensive support provided by his Company, Dr. Jackson had succeeded in settling the records and business operation down to an orderly procedure—a good base for launching the next phase of the Journal's business operations. During his term with the VJS, his responsibilities with Robertshaw Controls have expanded, and he has also accepted the responsibilities as the Chairman of the Publications Committee and editor for the Patent, Trademark and Copyright Section of the American Bar Association's Journal.

Mr. Kizer is completing 22 years as Supervisor of Science in the Commonwealth's Department of Education. His dedication and enthusiasm should lead to a successful promotion of the Journal. His address: Route #2, Box #637, Lancaster, VA 22503, and phone: (804) 462-7371.

The Academy has been fortunate in attracting two fine executives with keen business minds to run the business affairs during periods of editorial transitions and very critical moments of the VJS' further growth as an important journal.

### WELKER NAMED ASSISTANT EDITOR

Ms. Vivian Welker joined the staff of the Virginia Journal of Science on November 30, 1978. In the capacity of Assistant Editor, she provides invaluable assistance in continuing the improved quality of the Journal as it is brought back to schedule.

Ms. Welker received her B.A. (1978) in Hearing and Speech Sciences from the University of Maryland, and is pursuing her graduate studies in Speech Pathology at ODU. She brings to the Journal her prior experience in the field of advertising.

Her appointment has been made possible through the support provided by the ODU's School of Sciences and Health Professions.

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## NEWS AND ANNOUNCEMENTS

Membership Polled on VJS

Stewart Ware Named Next Editor of VJS

## MEMBERSHIP

The Academy membership is organized into sections representing various scientific disciplines.

Addressograph plates of all members are coded by a section number. The **First Number** indicates the member's major interest and enables Section Officers to more easily contact their members.

1. Agricultural Sciences
2. Astronomy, Mathematics & Physics
3. Microbiology (Bacteriology)
4. Biology
5. Chemistry
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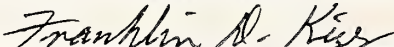
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## NOTES



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Articles (other than abstracts, correspondence and comments, and news and notes) should be sent to the Editor, Dr. Kuldip P. Chopra, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA. 23508. Manuscripts dealing with science and society, history of science and technology, correspondence, and news and notes should be addressed to the Associate Editor, Dr. Michael N. Bishara, Engineering Division, Southwest Community College, Richlands, VA. 24641. Short notes (not exceeding eight double-spaced typed pages, 2500 words or equivalent including illustrations) may be sent to the Editor or one of the members of the Editorial Board. Proofs, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

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WINTER 1978



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# VIRGINIA JOURNAL OF SCIENCE

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## DEDICATION



Phyllis Chopra

ABLE TO ACCEPT THAT A MAN CAN ALSO LOVE HIS WORK, PHYLLIS, MY WIFE, WAS FIRST AND FOREMOST MY FRIEND. IN THAT SHE PERMITTED ME TO SPEND UNTOLD EVENINGS AND WEEKENDS FOR WORK ON THE JOURNAL, THE TIME WHICH SHOULD RIGHTFULLY HAVE BEEN HERS TO COMMAND, THIS ISSUE IS DEDICATED TO HER MEMORY.



## Editorial

# PROLOGUE AND EPILOGUE

The Virginia Academy of Science is one of the strongest state academies. The rising costs, low circulations and disinterest of participating scientists have caused most state academies and many other scientific organizations to discontinue publication of their journals. In spite of the low membership dues, our Academy is one of the few which has managed to publish, though at irregular intervals, a scientific journal without assessing page charges. A journal is the living history of an academy, and its regular publication is a sign of the Academy's strength and vitality.

Our Academy has 15 active sections covering a broad spectrum of interests and disciplines ranging from agriculture to medical and space sciences. For its journal to be a meaningful medium of communication, it must contain articles containing new information on topics of wide appeal. These articles should be scientifically sound, and at the same time should be comprehensible to the membership at large. Recognition by authors' employers and peers has customarily required publication of sophisticated articles in national or international specialty journals. Most editors, and particularly those associated with quality journals with meager fiscal resources, demand brevity and conciseness. State academy journals have shoestring budgets, and their volunteer editors often work without stable support staff. This results in sporadic publication and lower circulations. All these factors work against the state academy journals, except for the diehards with a motto: *where there is will there is a way*.

In accepting the editorship of the Virginia Journal of Science, I had set the following goals:

1. Bring the Journal back on a regular schedule;
2. Expand the disciplinary and institutional coverage in the Journal;
3. Enhance the prestige and recognition for the Journal;
4. Improve the quality of the Journal;
5. Increase the size of the Journal; and
6. Provide, through fair success of the above, a foundation for building a fiscal base for continuation of the Journal.

The peer association and recognition formed the principal theme in our approach. The following distinguished scientists with extensive editorial experience were persuaded to serve on the newly formed Editorial Board:

*Dr. Walter Olstad*, Chief, Space Systems Division, NASA Langley Research Center, and Editor, *Journal of Spacecraft and Rockets*.

*Dr. Russell J. Rowlett*, Editor, *Chemical Abstracts Service*.

*Dr. Paul B. Siegel*, University Distinguished Professor, VPI & SU.

*Dr. Joanne Simpson*, W.W. Corcoran Professor of Environmental Science, University of Virginia, and Associate Editor, *Reviews of Geophysics and Space Physics*.

Dr. Siegel is a past President of the Academy, a past Editor of the VJS, and currently serves on the editorial boards of several national and international journals. Drs. David A. West (VPI & SU) and Charles O'Neal (MCV-VCU), the two immediate past editors of the Journal, agreed to join the Board to help provide continuity and smooth operation of the Journal.

It was felt that the Journal should develop a cross-disciplinary theme and introduce science and society features. Dr. Michael N. Bishara, Head of the Engineering Division at the Southwest Virginia Community College agreed to serve as the Associate Editor for Science and Society. To set our business affairs on an even keel, Dr. Auzville Jackson, Vice-President of Technology and Chief Patent Counsel at Robertshaw Controls Company, agreed to lend his name and skills as the Business Manager for the Journal.

To establish better communication with the sections and hence improve service to the membership, the role of *section editors* was revived and revitalized.

The Old Dominion University shares a common mission with the Academy in the propagation of new knowledge. Realizing the importance of the Journal to science in the Commonwealth, the School of Sciences and Health Professions at Old Dominion University made certain commitments, including release time for the Editor and part-time secretarial assistance in support of the Journal. Ms. Alarie Tennille and Mr. Ernest Maygarden of the ODU Research Foundation were named production editors.

Dr. West volunteered to complete Vol. 27 while we began to work on Vol. 28. His courteous response and ready accessibility helped us bring the Spring 1978 issue on time. Dr. Herbert McKennis of MCV-VCU, another past Editor, was frequently consulted in resolving some difficult problems associated with the Journal.

To publicize the new thrust of the Journal towards articles dealing with regional problems, announcements were sent for publication in *Physics Today*, *Aeronautics and Astronautics*, and the *Bulletin of the American Meteorological Society*. Frequent announcements on the Journal's progress and complimentary copies of Vol. 28 were sent to presidents and deans of various colleges and universities in the

Commonwealth. Letters of support were received from Presidents Thomas Graves (College of William and Mary), Thomas Law (Virginia State College), and Alfred Rollins (Old Dominion University). Presidents Rollins, William Lavery (VPI & SU), Dale Lick (Georgia Southern College), Dr. Donald Heath (Director, NASA Langley Research Center) and past VAS presidents Carpenter and Powell promptly sent guest editorials.

Because of the initial small flow of top grade papers and an uncertain fiscal picture, the size of the scientific issues of Vol. 28 was limited to 24 and 32 pages each. The editorial board and section editors were urged to help set the style and standard for the Journal by contributing and generating articles dealing with contemporary developments in science and technology and their impact on man and his environment. The prospective authors were assured publication of their articles within three months after acceptance, a promise we were not able to keep. This resulted in a significant increase in submittals during May-September, 1978.

During this same period, the Editor was without any help. Some at the host institution strongly felt that the Journal should be the responsibility of the Academy and the Editor. The top leadership in the Academy was also lukewarm and unsympathetic to the Journal, and felt that the Journal should be the responsibility of the Editor and his institution, apparently because their names appear on the inside cover. Lack of sensitivity and support for the Journal on the part of the Academy leadership and on-again off-again type support\* from the host institution led the Editor to indicate his desire in May 1978 to complete only Vol. 29 (1978). He later set a cutoff date of November 13, 1978 for receipt of papers for consideration of inclusion in the closing issue of this volume.

The proceedings issue had been delayed because the abstracts from one section arrived late in August, and the alphabetical listing of authors for this issue was not received until the last week of January 1979. (This list became the author index after pages were set and page numbers assigned). President Ulrich had insisted on the distribution of the scientific issues to follow the proceedings issue, hence the delay in our publication schedule. A quarterly again became a yearly, only to become a monthly once again. The

intent here is to emphasize the limitations, fallibility and mortality of the Editor's office.

Sixty-seven manuscripts (articles and short notes) were received before November 13, 1978. These papers, including those which were solicited or contributed by the editorial board and section editors, went through an identical review process. Forty papers were accepted after revision. The acceptance of papers was based on reviews and recommendations by 219 referees; one third of these were from out-of-state. The winter issues of Vols. 28 and 29 contain names and affiliations of 165 reviewers who consented to such listing. Three science and society essays and several additional features and reports have been introduced.

Contents of Vols. 28 and 29 at the back of this issue reflect the diversity in disciplinary and institutional coverage which has been achieved. These authors have affiliations with 31 institutions of higher learning and agencies of state and Federal governments within and outside of our Commonwealth. The material contained in these issues can compete with that in any national or international specialized journal. Our last two issues have acquired the respectable sizes of 69 and 94 pages each. The authors and reviewers have persevered and cooperated with greater promptness and enthusiasm than was expected, and the editorial board has provided valuable counsel. The skills and dedication Vivian Welker brought to the Journal on November 30, 1978 greatly helped in our catching up process at the time the Editor was hard-pressed.

The Journal is in its best possible shape and form at this time. The Academy is very fortunate in having attracted an energetic Editor and a wise, enthusiastic Business Manager. Your outgoing Editor has contributed a major portion of his 2½ years toward this Journal, and Old Dominion University has invested some of its resources. These contributions will be well rewarded if Dr. Stewart Ware and Mr. Franklin Kizer receive the needed support to lead the Journal to an even greater success.

It appears most appropriate to close with a slightly modified quote from Dr. Rollins (cf. guest editorial in Spring 1977 issue): The Virginia Polytechnic Institute and State University and the Medical College of Virginia have raised and nurtured this great publication through its infancy. We are proud to have had the opportunity to follow the noble traditions of our two sister institutions of higher learning in helping the Journal through its next phase of mature development.

*Kuldip P. Chopra*

\* Completion of this issue was made possible by a gift from the estate of Phyllis S. Chopra.



## CHALLENGES FOR SCIENCE

Dale W. Lick

*President, Georgia Southern College  
Statesboro, Georgia 30458*



The decades of the 50's and 60's saw an unprecedented growth in science in America. The prevailing attitude toward the science enterprise during this period was one of high expectation and almost blind faith. Today, however, perceptions are very different; there is substantial skepticism and an intense scrutiny of all aspects of science.

Much of this could have been foreseen. As scientists, we failed to appreciate that the scientific community had to be, as others in our society, accountable and responsive to the public, and that scientific endeavors had to be perceived as contributing significantly to the solution of national problems and to the enhancement of the quality of life. The public, of course, still believes in the value of science, but its awe has diminished, and the brightness of the star has dimmed.

### Importance and Responsibility

Although perceptions will differ greatly, the truth is that science remains vital. More than ever, America and most parts of the world have become complex, sophisticated technological entities, dependent on

*Dale W. Lick, president and professor of mathematics and computer science at Georgia Southern College, Statesboro, Georgia, received his B.S. (1958) and M.S. (1959) degrees in mathematics from Michigan State University, and Ph.D. (1965) from University of California at Riverside. He has extensive academic and industrial experience. He taught at Port Huron Jr. College, Univ. of Redlands, Michigan State U., U.C. at Riverside, Univ. of Tenn. at Knoxville, Drexel U., Temple U Medical School, and Old Dominion University. At several of these institutions, he held simultaneous administrative positions. He served as Vice-President for Academic Affairs at Russell Sage College and Dean of School of Sciences and Health Professions at Old Dominion University. His industrial experience spans line and staff management of Michigan Bell, and serving as computing technology consultant to Union Carbide and as applied mathematician at Brookhaven Nat'l Lab. He has authored two books and several research papers. A man of inexhaustible energy, Dr. Lick is very active in professional societies and community affairs. He made significant contributions to the development of education and services related to the sciences and the health professions in Virginia. He was dedicated to the cause of our Academy and the Virginia Museum of Science. He provided the Editor of the Virginia Journal of Science with moral encouragement and logistic support.*

modern science for their continuing operation and future advancement. The whole base for business, industry, agriculture, mass communications, in fact, almost every human endeavor, has become science oriented and science driven. We are past the point for our society to be otherwise. As Philip Handler, President, National Academy of Science, so aptly stated in the *American Scientist* (July-August, 1974):

"Science and the technology it makes possible, tomorrow as yesterday, will continue to constitute the principal tools available to this civilization for the improvement of the condition of mankind."

Accepting the critical and foundation role of science in our society, scientists must appreciate and come to grips with the consequences of the fact that science in America belongs to the people. Science is entrusted to the scientists of the day, and that trust is similar to the confidence placed in the hands of the physician upon taking the Hippocratic oath. It carries with it a broad set of ethical responsibilities relating to the use and development of science and its resulting technology. Consequently, scientists' moral and intellectual allegiance must be to the public. A

good perspective on this comes from Frank Press in *Science* (May 19, 1978):

"The quality of our science will reflect our pursuit of excellence throughout our entire society—our education, our public concerns and interests, and our institutions. Our technology will never be fool-proof or fail-safe, but always dependent on the human factor—the quality, dedication, and responsibility of our workforce."

### Viability, Perception, and Change

From 1953 to 1965, federal allocations for science research and development grew dramatically from 2.8 billion dollars to approximately 12.6 billion dollars. However, from 1966 to the present, federal support has increased at a rate of only one percent per year. Certainly this deceleration in support during the late 60's and into the 70's lessened the viability of science significantly and raised doubt as to the public's commitment to and level of belief in science. Why did this happen? At least in part, it happened because science failed to effectively communicate its own story. Too often the public was expected to feed the kitty, not ask questions, and take for granted the importance and wonderfulness of science.

Unfortunately, or fortunately, as the case may be, the public's perceptions often are that science has lost sight of the peoples' needs and that scientists frequently care more about their own work than about serving society. This has brought shocking realities. If science is to remain viable, scientists must communicate more effectively, must re-examine priorities, must put the people and society's needs ahead of their own personal preferences, and must be responsive to the perceptions and wishes of the nonscience community.

Stop and think about it for a moment. Have we often let our professionalism serve largely to insulate us, to expand the power of the profession and to stipulate privileges of professional life and obligations owed the profession rather than duties and services owed the public? Of course we have! Too many times we have ignored our final responsibility. This is nicely summarized by William Bevin in *American Scientist* (November-December, 1971) when he quotes Alexander Meikeljohn:

"Our final responsibility as scholars and teachers is not to truth. It is to the people who need the truth."

and then goes on to explain:

"This special insight closes the gap between students and teachers, between universities and the real world, and between the reality of the 50's and 60's, which most of us have taken for granted, and the new realities of the 70's and 80's."

As humans, scientists have a tendency to follow the traditional paths of the past and of their professions. Instead, we must overcome our parochialism and build into ourselves and our systems mechanisms for change. We must do as the following anonymous poem says:

"Do not follow where  
the path may lead.  
Go, instead, where  
there is no path  
and leave a trail."

We must not only be receptive to change, but directive of it. Needed is a form of change that is purposeful, not merely adaptive, that retains relevance without abandoning inherited validities; a change characterized by "the scholar's caution *and* the scholar's courage."

### Challenges

Science and the science community have provided Americans with the foundation on which to build a great nation. The opportunities for further advances in science are enormous, and the pursuit of science has never been more exciting. However, to realize the full potential of science in the future, we must:

1. Set priorities and institute changes to make science more responsible to the public and responsive to its needs.
2. Re-ignite the belief that science is an indispensable ingredient in solving the major problems facing mankind, and that scientists are concerned developers of relevant tools, flexible in their attitudes toward applications and aiding others in the use of science to solve their problems.
3. Review present capabilities and develop new academic and research programs for future innovative directions in science.
4. Better document the case for science and more effectively present it to employers, administrators, funding agencies, legislators, and the general public.

If we will only help make it happen, science can be simultaneously professionally strong *and* relevant and responsive to the society supporting it.

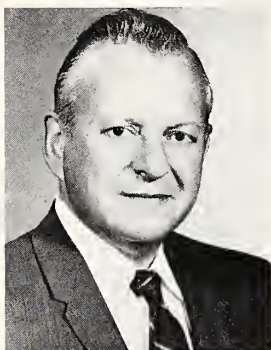


# Planning Electricity Research and Development Alternatives—Coping with Uncertainty

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**Abstract**—Since the oil embargo a few years ago, the energy future of the United States has been clouded with uncertainties regarding the growth of demand for energy, resource availability, and technological development. These uncertainties are further compounded by the interplay of social, economic, political, and environmental issues. Due to the vital effect of energy on our economic well-being and the lengthy time needed to develop new technologies, grave concerns have been expressed by both the general public and private industries. This paper describes some of the considerations and logic that entered into the planning process at the Electric Power Research Institute, the R&D arm of the electric

utility industry, in a joint effort with the government and other energy industries to ensure that our nation's future welfare will not be constrained by potential consequences of these uncertainties.

It first presents an analysis of the overall framework of U.S. total energy requirements and supply and establishes the role of electric energy. Projections of resources availability are then presented. From this information, the magnitude of the potential shortfall in electric energy supply and the degree of uncertainty are estimated. Attention is next given to the role of environmental research in the EPRI R&D plan. Finally, details of several R&D alternatives and the probable time frame of their availability are presented.

## Introduction

Since the oil embargo a few years ago, the energy future of the United States has been clouded with uncertainties regarding the growth of demand for energy, resource availability, and technological development. These uncertainties are further compounded by the interplay of social, economic, political, and environmental issues. Due to the vital effect of energy on our economic well-being and the lengthy time needed to develop new technologies (usually 20 to 30 years), grave concerns have been expressed by both the general public and private industries. In concert with efforts from other sectors, the nation's electric utilities have already joined forces to embark upon an aggressive research and development program to ensure that our future national welfare will not be constrained by the capability to supply the desired electricity.

The Electric Power Research Institute (EPRI), the R&D arm of the electric utility industry, has examined these uncertainties as it developed a plan directed at providing timely availability of the needed technical alternatives to accommodate the limiting case.

This article will describe some of the considerations and logic that entered into the development of the EPRI plan. The next section presents an analysis of the overall framework of U.S. total energy requirements and supply and establishes the role of electric energy. Projections of resource availability are then presented. From this information, the potential electric energy supply issues are identified and the degree of uncertainty is estimated. Attention is next given to the role of environmental research in the EPRI R&D plan. Finally, details of several R&D alternatives and the probable time frame of their availability are presented. It should be pointed out that although the EPRI plan focuses on electricity, it complements the R&D planning activities of the U.S.

Department of Energy (DOE) and other energy industries. In many of the examples described in this paper the research is proceeding on a joint basis.

### Total U.S. Energy Requirements and Supply

EPRI is primarily interested in electricity requirements. However, in the process of developing its R&D plan, it needs to estimate total energy consumption as well. Over the next several decades, energy consumption will likely be marked by consumer switching from natural gas and oil to electricity and coal. Consequently, assumptions about total energy needs are necessary to anticipate the amount of switching from primary fuel to electricity. Projections of total U.S. energy demand also provide a measure of the future competition among primary fuels and the effect of this competition on utility fuel costs and on the markets for advanced technologies.

From 1950 to 1973, energy consumption in the United States has increased at an average annual rate of 3.5 percent (Dupree, 1976). The average growth rate was even greater, 4.1 percent, from 1960 to 1973. However, following the oil embargo, energy consumption decreased. Even though the downward trend lasted only a short duration and energy consumption since 1975 has again increased on an average of more than 3 percent per year, significant uncertainties exist in projections of the future rate of growth in total energy consumption. Several independent studies were conducted by EPRI to develop a high and low projection of future total energy needs. These projections placed the average annual energy growth rates to the year 2000 between 2.4 and 3.4 percent per year, all below recently experienced historical rates. The energy requirement in the year 2000 is shown as ranging between 117 and 158 quads (see Figure 1). Growth continues in the post-2000 period, but the rates are decreasing.

Of the 77 quads of fuel consumed in 1977, 37 were provided by petroleum and 21 by natural gas.<sup>1</sup> By the year 2000, natural gas production is expected to be, at best, no greater than it was in 1977. Projections of petroleum are clouded by political and economic uncertainties. The combined resources of petroleum and natural gas are expected to provide only one third to one half of our energy needs, rather than the current 75 percent. *The major supply problem will be providing resources to fill the gap resulting from petroleum and natural gas limitations.*

The two most readily available resources are coal and uranium. Hydropower is not expected to increase greatly because of the value being placed on undisturbed wilderness areas and watersheds. Geothermal energy holds future potential as a substantial source of energy in the west and southwest; however, because of technical and economic obstacles, environmental considerations, geology, and the site-specific nature of the resource, its national contribution up to the year 2000 is likely to be limited.

Solar energy for heating and cooling is beginning to enter the commercial stream, and it is anticipated, in the long run, to be a substantial substitute for oil and gas, the current primary heating fuels. Nevertheless, the rate of application of solar heating sys-

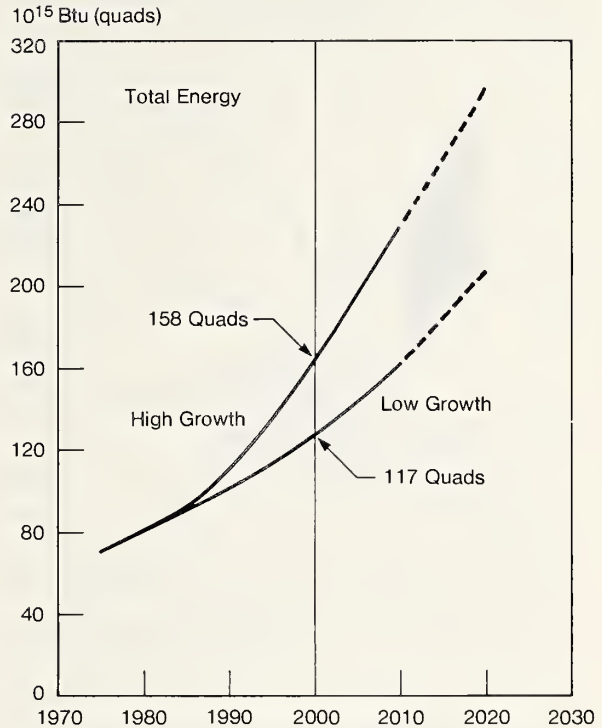


FIG. 1—Projections of U.S. energy demand.

tems will be influenced by the number of housing starts, the extent to which existing residences are retrofit, and the ability of solar heat to be economically competitive. Currently, the residential and commercial segments consume approximately 35 percent of the nation's total energy output, about half of which is used for heating (Starr, 1976). If solar heat could supply 20 percent of residential and commercial space heating by the year 2000, it could account for 3 percent of the U.S. energy use in that year.

As petroleum and natural gas become less abundant, their distribution may shift to those critical areas which lack the flexibility to utilize a different resource. For example, certain segments of our society, such as transportation, are less fuel-flexible than others. Resources that can substitute for petroleum and natural gas will be needed for the remaining sectors. It must, however, be realized that the success of a substitute resource will again be a function of its economic attractiveness, environmental acceptability, and flexibility in application.

The interplay of these criteria can be illustrated by examining coal, which is both abundant and economically acceptable. Although coal could substitute for oil and natural gas for such functions as residential heating, the potential environmental effects could be substantial. It is important that this resource should substitute in ways that allow economic control of environmental emissions. For example, emission control of direct-fired coal could probably be more economically feasible than in larger capacity utility and industrial installations than in individual homes. Because electricity can expedite the replacement of pe-



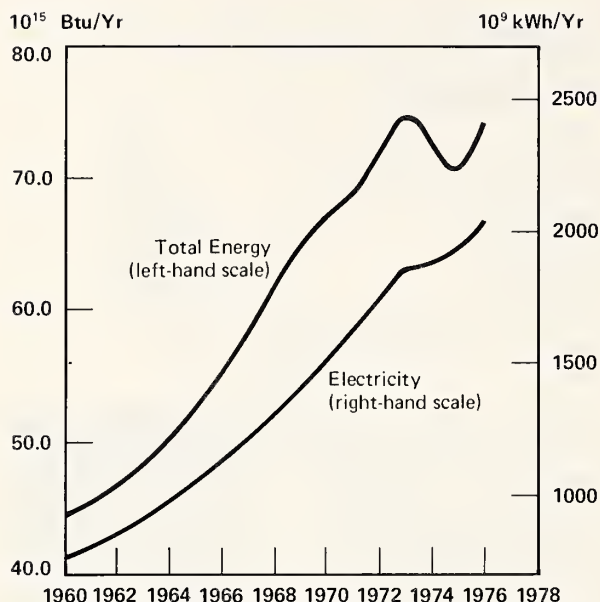


FIG. 2—Growth in annual energy consumption and electricity generation by electric utilities: 1960–1976.

troleum and natural gas with available indigenous resources, such as coal and nuclear power, in an economically and environmentally acceptable way, it should be an important factor in filling the energy gap to the year 2000 and beyond.

### Electricity Growth Rate

Historically, the growth rate in electricity consumption has exceeded the growth rate for total energy. Figure 2 demonstrates that, from 1960–1976, while total energy consumption increased by approximately 60 percent, electricity consumption almost tripled. Between 1947 and 1975, the growth rate for electricity consumption was 7 percent.<sup>2</sup> Following the oil embargo, the national total energy usage in 1973 and 1974 decreased to below the 1972 level. Yet, during the same period, the use of electricity held constant. In 1976, the increase in the use of electricity was 6.4 percent, reflecting the improvement in economic conditions, higher employment and substitution of electricity for other energy forms. In 1977, the annual growth rate of electricity consumption was about 5 percent.<sup>3</sup> Estimates of future electricity growth rate are still marked by uncertainties stemming from rising energy costs, shortages of competing fuels, environmental concerns, confusing signals from governmental agencies, and the unknown effect of appeals for energy conservation.

Projections of future electricity usage using the Energy Technology Assessment (ETA) model (Manne, 1976) show the percent of total energy used for electricity generation increasing from the current value of 30 percent to between 40 and 57 percent in the year 2000 (see Figure 3). These percentages of the total energy projection shown in Figure 1 result in an electricity consumption in the year 2000 in the range from 5 to 9 trillion kWh, as shown in Figure 4,

equivalent to average electricity growth rates of 4.0 to 6.6 percent each year between 1975 and 2000. These rates decrease during the first 20 years of the next century as a result of the reduced growth of population and gross national product.

When a single growth curve is used for planning, a nominal value of 7.0 trillion kWh in 2000 is used. Projections from many other sources fall within a range of 4.6 trillion to 9.1 trillion kWh in the year 2000. Such projections must be viewed with recognition of the key assumptions used in the analyses. Some of the low projections are based on optimistic assumptions regarding the relationships between energy, jobs, conservation, and economic output of the nation. Other low projections postulate rapid changes in energy consumption by the people of the nation, which in turn imply drastic changes in lifestyle. Conversely, high projections did not consider the impacts of conservation. An adequate R&D program plan must recognize conservation as an essential tool in balancing the nation's energy demand and supply. Therefore, energy conservation, both in the electric utility system and at the end use, is an important part of the EPRI research and development program.

While economic incentives have always existed to use energy resources as efficiently as possible, rising costs should stimulate additional interest in the reduction of utility system losses and in the application of more efficient end-use devices. In addition, national policies could also alter consumer practices toward greater conservation of energy resources. Regulatory actions to increase home insulation or to require the use of more efficient small automobiles

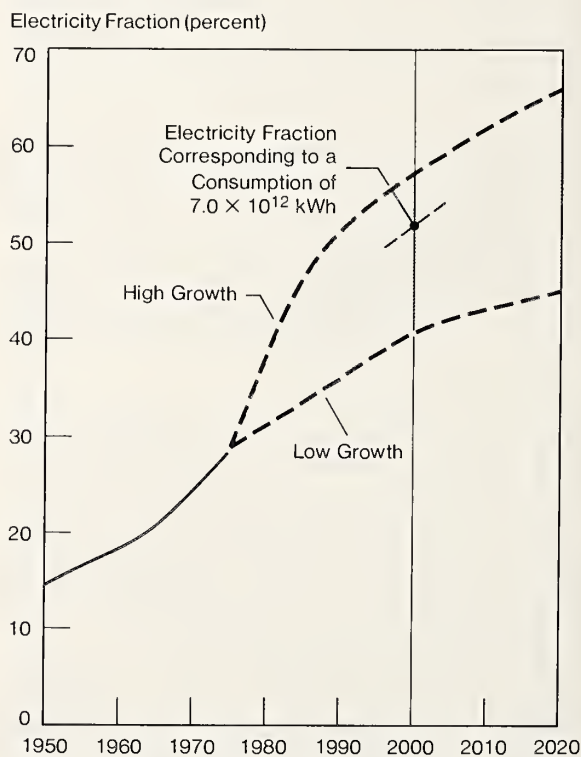


FIG. 3—Expected range of the electricity fraction.

are examples of potential nonprice-induced conservation practices.

This emphasis on the efficient use of energy could have both positive and negative effects on electricity requirements. More efficient electric appliances and manufacturing processes would reduce electricity use, but the national goal of reducing dependence on oil and natural gas could result in the use of fuel-saving devices (such as heat pumps, solar heating, solar cooling, heat recovery systems, and electric automobiles) which could actually increase the need for electric energy.

Using a detailed initial survey of the potential for technological conservation (Smith, 1976), the EPRI planning projection of  $7.0 \times 10^{12}$  kWh (Figure 4) incorporates an estimated conservation saving of 17 percent in electricity consumption through improved efficiency of end-use devices.

### Resource Availability for Electricity Production

The availability of primary resources and the fuel mix for electricity production was studied over the range of projected electricity consumption. This study, using the ETA model, considered a period from 1975 to 2020. The fuel needs of both the electric and the nonelectric sectors were evaluated to understand the competing requirements, to determine the effect of price changes, and to explore the prospects for fuel switching by the ultimate customer. Estimates were made of the amount of energy that could be supplied by hydroelectric, geothermal, and solar electric systems. In addition, the use of oil and natural gas for electricity production was projected as declining during the next few decades. The analysis showed that approximately 85 percent of the electricity requirements in the year 2000 must be generated using uranium and coal. In 1975, 52 percent of the nation's electricity was generated using these two resources (Dupree, 1976).

The major question becomes *Can the production of coal and uranium be sufficient to supply the projected electricity needs over the next three or four decades?* In 1976 the electric utility industry used 67 percent of the 0.67 billion tons of U.S. coal production,<sup>4,5</sup> for

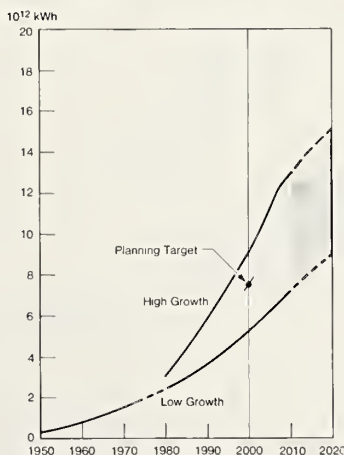


FIG. 4—Range for estimated annual electricity consumption and base figure used for research planning.

### ELECTRICITY GENERATION MIX 1975 to 2020

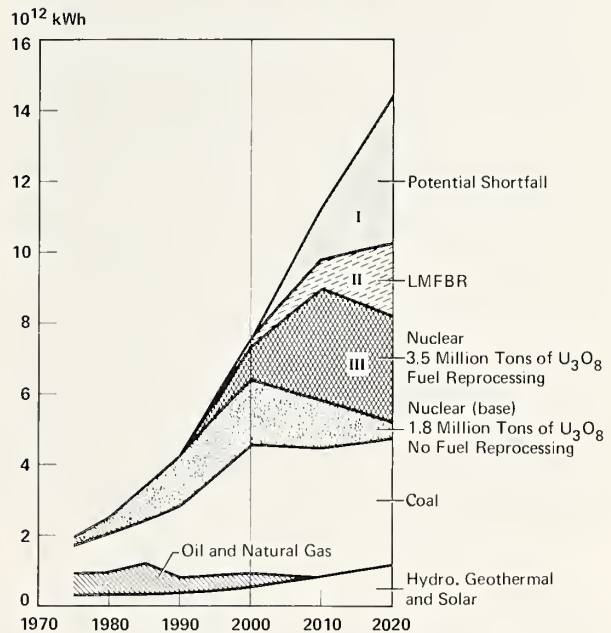


FIG. 5—Projected electricity generation mix.

this study, coal production was realistically constrained to 3.4 times current level in 2000, 4.5 times in 2010, and 5 times in 2020. In addition, the economically recoverable domestic uranium supply was estimated as being between 1.8 and 3.5 million tons (Dupree, 1976). The results of this study for a nominal electricity growth rate are shown in Figure 5. Electricity produced from coal and conventional reactors will dominate the period from 1975 to the year 2000. Beyond 2000, a potential shortfall in electricity production is indicated unless coal production can be further increased, greater amounts of uranium become available to extend the nation's nuclear option, or advanced options can be accelerated. With low uranium reserves of 1.8 million tons of  $U_3O_8$  and no fuel reprocessing, the shortfall is represented in Figure 5 by the sum of the shaded areas I, II, and III. Under this scenario, the potential shortfall would grow rapidly.

The magnitude of the potential shortfall underscores the importance of research programs to increase the usability of existing fuel resources. Reserves of 3.5 million tons of  $U_3O_8$ , together with fuel reprocessing, would reduce the shortfall significantly. Another part of the shortfall could be supplied by the introduction of the breeder reactor, which would multiply the equivalent availability of uranium by a hundredfold. The breeder reactor is shown as being introduced at a rate which is optimistic relative to today's national program. This projection shows 6 liquid metal fast breeder reactors (LMFBR's) in operation in 2000 and 70 in 2010. It is believed that this is about as rapidly as the industry could grow and is somewhat more rapid than the rate achieved by light water reactors between 1960 and 1975.<sup>6</sup>



Analyses conducted to date show that competition for coal after the year 2000 may place a constraint on continuous growth in coal-fired electricity production. By this time period, the nonelectric sector of the economy will also need to find a replacement for natural gas and petroleum. Synthetic fuels from coal are considered to be an attractive alternative for this energy substitution, and the resulting demands on the coal supply are large. This finding suggests the need for major support of research on advanced options for electricity production. It also provides motivation for work on more efficient coal conversion systems and coal-derived clean fuels to allow utilities to reduce consumption of the natural gas and petroleum needed by other sectors of the economy.

The plan is based on the premise that five percent of the total electricity requirements in the year 2000 will continue to be supplied by petroleum. This energy would be required primarily for peaking service. If the supply of this resource for utility use were denied, *significantly accelerated research would be required on coal-derived liquid fuels, load management, and electricity storage technologies.*

### Environmental Requirements

In addition to the uncertainties that exist in future electricity requirements and energy supplies, equally important doubt can exist in relation to the environmental and regulatory situations at the end of this century. At EPRI, environmental assessment activities receive a high priority. Ideally, the results of such work should be available preceding the establishment of environmental standards. Historically, however, this condition has not prevailed. The objective of the EPRI environmental assessment program is to ensure that environmental standards are established on a sound scientific footing.

Parallel to environmental assessment activities, a major part of the EPRI research and development program is devoted to *improved control of environ-*

*mental effects arising from utility system operations.* However, even more importantly, the anticipation of more stringent future emission and safety standards further spurs the urgent need of technologies for *increasing the environmental acceptability of existing resources*, such as research on coal gasification and liquefaction processes.

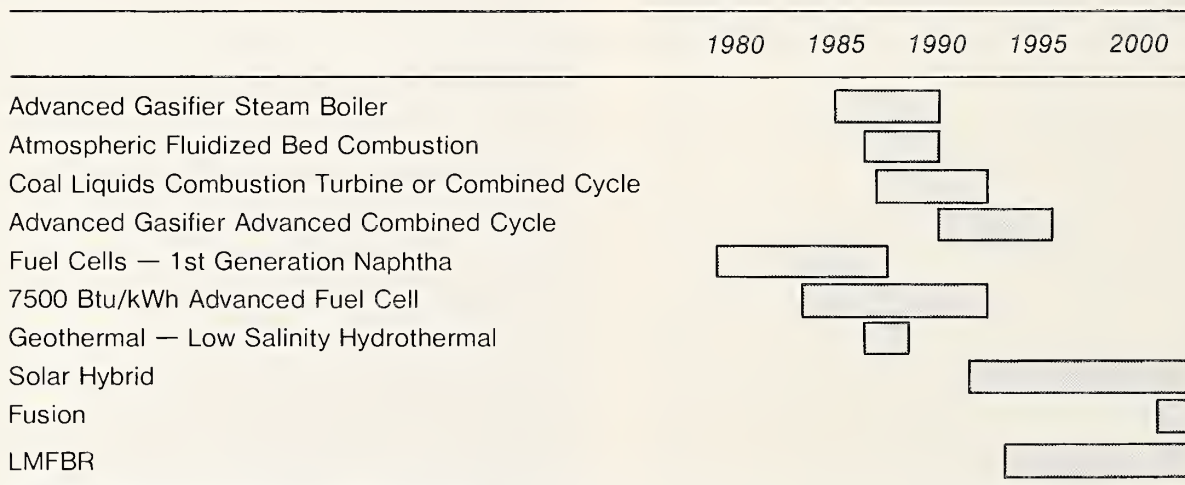
### Timing of R&D Alternatives

Ensuring the timely availability of these alternatives is one of the most important considerations in the planning of current energy research and development. A window, or optimal entry point, exists for each new technology. For example, the window for processes to economically produce liquids and gas from coal begins in the late 1980's. Beyond the year 2000, a high probability exists that the requirements for petroleum, gas, uranium, and coal will exceed the projected production capability of these resources. Consequently, LMFBR could begin to make substantial contributions to the electricity supply during this period. The opportunities for other options, such as advanced solar power, advanced geothermal energy, and fusion power, could occur during the first few decades of the next century.

Timeliness represents a key question—*can new options be developed and ordered on a commercial, non-experimental basis when needed?* The ensuing descriptions of the current R&D state of several energy alternatives will include estimates of availability. Developments in the following areas will be addressed

- Coal-derived liquids and gases,
- Electrochemical fuel cells,
- Geothermal energy,
- Solar energy,
- Fusion, and
- Nuclear option.

Today, many of these developments are in the design or pilot plant stage. Upon completion of current experiments, demonstration units must be built and



NOTE: Length of bar indicates uncertainty

FIG. 6—Potential availability for first commercial orders.

operated. Only after the operation of these units can any of these options be ordered with a minimum of developmental risk. An analysis of the steps required to achieve a developed technology for each of these alternatives results in the projections shown on Figure 6. The bands represent uncertainty in the estimate of time at which an initial order could be placed. Approval and construction times must be added to these dates to determine initial operation.

*Coal-derived liquids and gases*—Current technology for the generation of electricity from coal in an environmentally acceptable manner is based on the removal of the  $\text{SO}_2$  and particulates from the power plant exhaust following combustion. The operating experience on these flue gas desulfurization (FGD) systems has been marginal. While some new FGD units have demonstrated high reliability, further operating experience is needed before a final conclusion on their operation can be reached. The disposal of the sludge developed in the scrubber remains a major problem. Large areas are required to store this waste material, which represents a substantial environmental issue. Development work is underway on regenerative processes that will remove the sulfur and recycle the limestone.

In addition, flue gas desulfurization systems substantially increase the cost of coal-fired steam-generating units and result in about a 10 percent reduction in efficiency, resulting in a heat rate of 9800 Btu/kWh. A strong motivation, therefore, exists to develop a means of using coal in high-efficiency systems with heat rates of 7500 Btu/kWh.

One alternative to removing the sulfur after combustion is to remove it during combustion. For example, in fluidized bed combustion systems (FBC), heated, crushed coal is mixed with air and limestone, causing the sulfur dioxide formed during combustion to chemically react with the limestone. Currently, coal-fired boilers must be designed to the specific characteristics of the coal to be burned. FBC might be able to serve as a universal design to burn any type of coal. The heat rate in a FBC boiler system could be 9500 Btu/kWh. A Department of Energy (DOE) supported FBC pilot plan is currently being tested at Rivesville, West Virginia, while EPRI is supporting a fluidized bed development test facility at Alliance, Ohio.

Recognition of the time required to demonstrate this technology leads to the conclusion that an initial order for such a system on a nondevelopmental basis could be placed in about 1986. However, the uncertainty exists in this availability date of at least four years, as shown in Figure 6.

Other coal options, with the potential for commercial application in the 1980's and 1990's, are gasified coal in steam boilers, coal-derived liquids, and advanced coal gasifiers with combined cycles (combustion turbine with steam bottoming cycle).

Engineering evaluations of advanced gasifiers supplying fuel for combined combustion turbine-steam bottoming cycle generating units show the promise of attaining overall heat rates from coal to electricity of 7500 Btu/kWh.<sup>7</sup> Therefore, coal-derived clean fuels are being developed to provide low and intermediate Btu gases for the generation of electricity. A coal

gasification process combines coal, air, and steam to produce coal gas. Particulate matter and sulfur are scrubbed from the gas in a continuous operation. This gas can be used in a steam boiler or a combined cycle power plant. The combined cycle systems offer the potential for reduced electricity costs and higher efficiencies. Hence, much of the present development effort is directed toward coal gasifiers integrated with combined cycle systems.

Gasification combined cycle experiments are planned to examine the characteristics of such systems. Original EPRI interest centered on the test of a Lurgi-type (fixed-bed) gasifier, but current emphasis is on the Texaco entrained gasifier close coupled combined cycle to be tested in a 100 MWe unit at the Coolwater Station, California.

Advanced systems, such as entrained coal gasifiers, would allow the use of all types of coal. In an entrained gasifier, coal particles are not in contact with each other, but are swept along by the gas stream. Therefore, the particles do not cake. Such processes necessitate fewer reactors and less equipment to produce the required gas, thus reducing capital costs as well as operating and maintenance requirements (Loth, 1977).

Coal-derived liquids represent another future energy source for the generation of electricity. Liquids are produced from coal by the reaction of coal with hydrogen. Contact with hydrogen is accomplished in such a way that significant amounts of organic sulfur, nitrogen, and oxygen are reacted and, therefore, removed from the coal. Further processing of the primary product of the liquefaction reaction removes inorganic sulfur and other mineral matter. H-Coal and the Exxon Donor Solvent (EDS) Process are examples of important coal liquefaction development programs.

H-Coal is a direct catalytic process in which a slurry made from coal and recycled solvent recovered from the process is contacted with hydrogen in a reactor containing a catalyst. The amount of hydrogenation is controlled by the temperature, pressure, coal throughput rate, and the activity of the catalyst.

The EDS Process is the most advanced of the indirect catalytic processes. It differs from H-Coal in that the recycled hydrogen donor solvent is catalytically hydrogenated in a separate reactor prior to being mixed with coal. This slurry is then mixed with hydrogen and reacted in a noncatalytic reactor. Products from this process are generally in the light fuel oil and turbine fuel range and are low in nitrogen, sulfur, and oxygen.

The expected commercial availabilities of a combination of alternative technologies for coal-derived liquids and gases are shown in Figure 6.

*Electrochemical fuel cells*—Fuel cells, which were developed for spacecraft and military applications, are another future energy alternative. A fuel cell produces energy through electrochemical reaction rather than through combustion. Therefore, since it is not limited by Carnot's second law of thermodynamics, its efficiency can be higher than that of thermal machines.

The fuel cell would offer further advantages in siting, since it can meet urban air or noise environ-



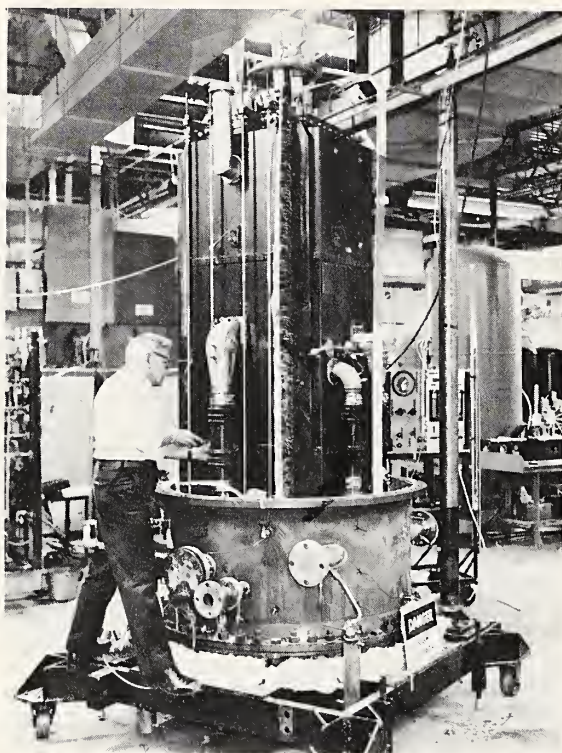


FIG. 7—4.8-MW fuel cell demonstration.

mental requirements. Being modular, the units can be tailored to meet both large and small dispersed generation needs. Thus, a fuel cell plant might be used to provide electricity and heat in the heart of a metropolis, as well as to provide energy for small, decentralized rural areas.

A 4.8-MW first generation fuel cell demonstration module, shown in Figure 7, is being constructed. It will be installed in New York City in 1979, and testing will continue for two years. The heat rate of this module is 9000 Btu/kWh. Second generation fuel cells, currently in the R&D stage, are expected to have a heat rate of 7500 Btu/kWh. An important constraint upon the fuel cell is fuel availability. It provides clean, highly efficient utilization of petroleum and distillate fuels, but petroleum is expected to be severely limited. Figure 6 illustrates the expected

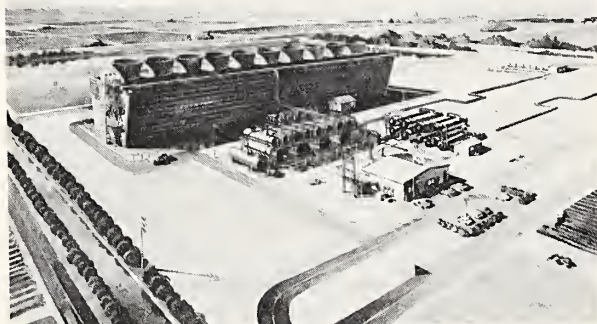


FIG. 8—Low salinity geothermal demonstration plant, Heber, California

commercial availability of first generation fuel cells using naphtha and second generation units using coal-derived fuel. Second generation fuel cells are also being examined for their ability to integrate with coal gasifiers.

*Geothermal Energy*—Low salinity hydrothermal (hot water) generating units are shown in Figure 6 as an option in the mid-1980's. At present, about 500 MW of geothermal generating units are operating at The Geysers in Northern California. By 1986, the capacity of this site could reach 2000 MW. The Geysers' generating units utilize dry steam, the geothermal source which is the easiest to use. The steam is used directly to power turbines. Unfortunately, this source is also the rarest, constituting less than one percent of the total geothermal resource potential.

Substantial amounts of energy exist in hot hydrothermal reservoirs at varying depths and pressures in the western and Gulf Coast states. A proposed 50-MW demonstration plant at Heber, California (Figure 8) will be used as the basis for examining the environmental, technical, and economic factors associated with the use of such a hydrothermal source.

Beyond hydrothermal sources, geopressure is the next resource to be examined for commercial use. Geopressure reservoirs are located at greater depths than low-salinity hot water or dry steam resources, and contain water under high pressure. The fluid from geopressure wells also contains methane, which would be of value.

Approximately 70 percent of geothermal energy is in the form of crystalline rock and magma. To utilize this abundant source of geothermal energy, technology is needed to extract the energy from deep in the Earth and then convert it to electricity at the surface. The geologic and technical feasibilities of recovering this energy are unknown. Geopressure also represents a potentially large but uncertain resource that is in the experimental stage of development.

All of the geothermal resources present developmental challenges. For example, consideration must be given to the environmental impacts of ammonia, hydrogen sulfide, and even radon in the geothermal fluid. In addition, there are unanswered questions regarding the effect of geothermal energy utilization on seismic activity and land subsidence. The availability of water at some of the sites in dry western states may also present a problem.

The estimated long-range potential of geothermal energy is potentially high for the western regions, but the aforementioned factors, as well as the time required for a new technology to make a significant impact, will limit the growth of geothermal power over the next two decades.

*Solar Energy*—The term "solar energy" is often used loosely to encompass several energy options—solar thermal energy, biomass, ocean thermal energy conversion, and photovoltaic energy. Many types of solar heating devices are currently commercially available, but much attention to the economics and quality of these systems is needed before complete customer acceptance is possible. Several thousand experimental solar buildings have been or are being



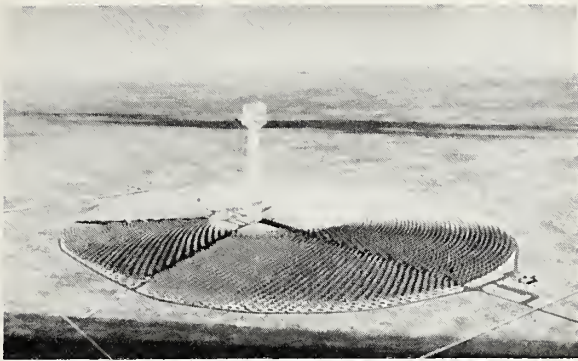


FIG. 9—60-MWe open cycle gas turbine solar electric plant (artist's conception).

built in the country. Some 350 projects on solar heating and cooling, including systems used in combination with heat pumps, are being sponsored by the electric utilities throughout the nation. The feasible and economic choices should surface from this effort. The development of the equipment and systems to use this energy source represents an important developmental challenge. Low-cost, reliable, long-life equipment (15 to 20 years) must be developed to reap the benefits of this energy source.

The potential of providing electricity from solar energy is also being explored. Sunlight, reflected from controlled mirror sun tracking (heliostats) could be used to heat water and produce steam in a boiler located at the top of a tower, as shown in Figure 9. The steam would then be used to power a conventional turbine generator. A heliostat field approximately one mile across would be required for every 100 MW of generation. The capital cost of such a plant is estimated to be three to five times that of a conventional fossil fuel plant of the same capacity. For solar-electric power plants to become commercially competitive, the mirrors must be produced for below \$15 a square foot.

The availability of this option on a commercially competitive basis is most uncertain. The earliest date shown in Figure 6 is about 1990 with the band extending to the post-2000 period.

A version of the thermal electric system that is of interest to EPRI is a hybrid Brayton cycle. In this system, solar energy is needed to heat air or helium, which is then used to drive a gas turbine (Brayton cycle) to generate electricity. Since this system does not require cooling water, it would be attractive in many of the arid areas where solar energy is most available. The cycle is designed so that oil or coal-derived liquids can be used as an energy source to fire the gas turbine when the sun doesn't shine.

Solar thermal systems function on direct sunlight; hence, their application will be limited to areas without much cloud cover. As can be seen in Figure 6, there is considerable uncertainty regarding the time at which a commercially economic solar-thermal conversion system could be ordered.

Photovoltaic energy conversion systems have the advantages of using diffused sunlight and requiring no cooling water. Present manufacturing costs of solar cells must be reduced by a factor of 100 before

solar cells can be economically competitive. Among the developmental approaches to achieving this goal are cadmium sulfide cells, crystal silicon cells, and gallium arsenide cells.

**Fusion**—If the technical barriers can be removed, fusion offers the promise of almost limitless energy. To permit the controlled release of nuclear fusion energy, hydrogen isotopes must be fused at extremely high temperatures (100 million degrees C) under proper confinement and particle density.

The scientific feasibility of fusion has yet to be demonstrated, and aggressive programs are underway on a number of approaches to this goal. The key efforts can be divided into magnetically confined experiments and inertial confinement by laser systems. For example, a tokamak (TFTR) plant is currently being built at Princeton's Plasma Physics Laboratory (PPPL), which could achieve the necessary conditions to show scientific feasibility. The plant is scheduled for completion by 1981.

Current technical designs for fusion plants based on magnetic confinement indicate the possible need for high capacity units; therefore, EPRI is studying several concepts that may lend themselves to smaller sized plants. Among these are inertial confinement systems using high-powered lasers and electron beams. An array of technical concepts must be explored before the optimum fusion system can be determined. Commercial availability is not expected in this century.

**Nuclear option**—The electricity that can be supplied by the current nuclear option based on the light water reactor (LWR) is shown in Figure 4. Uncertainty exists in the supply of economically attractive  $U_3O_8$ , so the projections are shown for 1.8 and 3.5

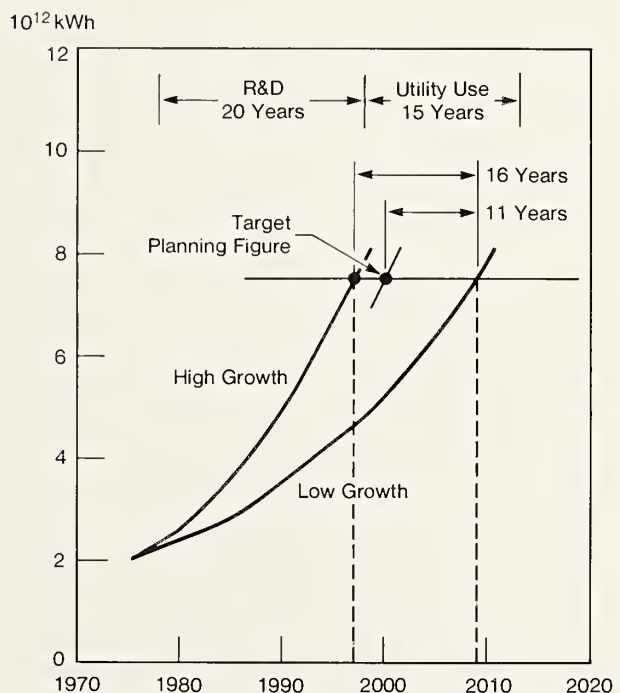


FIG. 10—Effect of high and low electricity growth rates on time of occurrence for electricity use of 7.5 trillion kWh.



million tons. The introduction of the liquid metal fast breeder reactor (LMFBR) is shown in 1995 at a rate that could be optimistic, considering the current status of this technology in this country. It would then be possible to introduce a number of commercial liquid metal fast breeder reactor plants during the 1990's. Even with this rate of introduction, the application of the liquid metal fast breeder reactor is much later than needed.

The uncertainty regarding the time when a LMFBR unit could be ordered on a non-developmental basis is substantial. Figure 6 shows this date extending from 1994 to 2000.

Meanwhile, a worldwide survey of the breeder programs indicates that other industrial nations are proceeding rapidly with their own projects. Now that experience has accumulated from the successful operation of the Phenix reactor, the French breeder program centers around the 1200 MWe Super Phenix. The design of this plant has been completed, and construction began in 1977. The British PFR plant in Dounreay currently supplies power to the electric grid at 100 MWe out of the 250-MWe rated capacity. Full power is expected to be achieved by 1978. The USSR now operates both the BN350 and the BN600. The design of a large 1000-MWe pool-type breeder, which will form the backbone of the future Russian nuclear industry, is now being pursued.

### Conclusions

The large uncertainties existing in future electricity demand growth, fuel resource availability, environmental regulations, and energy technology developments have been explored in detail. A fruitful research aim should be the acquiring of sufficient understanding and knowledge to place a higher confidence level on projections of this type. Nevertheless, when it is necessary to anticipate events for three or more decades, it is extremely unlikely that a high confidence level of understanding can be achieved. As today's uncertainties become better understood, it is likely that a new set of unknowns and concerns will arise that will affect electric utility systems. It is therefore essential<sup>8,9</sup> that strategic principles be followed which have the flexibility to cope with new situations (Starr, 1976, 1977). Such flexibility can be approached by basing R&D program plans on a plausible future projection. Contingency analysis and planning can then be used to respond to possible pessimistic outcomes and limiting conditions. For example, the EPRI plan assumes a nominal 5.3 percent average annual growth rate projection of electricity demand from 1977 to 2000. Yet, considerable thought has been given to the consequences of possible higher or lower electricity consumption growth rates.

The underlying logic of this prudent approach may be explained by examining Figure 10, which shows the range of projected growth rates of electricity. If, for example, the lower growth rate of, say, 4.0 percent a year does materialize, the time when new transmission and distribution developments are needed might be postponed. Such action, however, would

not be appropriate with advanced electricity generation options, because of the long time periods required to first develop (20 to 25 years) and then introduce (10 to 20 years) the new technology. As shown in Figure 10, the use of 7.0 trillion kWh occurs about 11 years later for the low growth case than for the 5.3 percent/year growth rate. This time increment is short compared to the 30 or 40 years needed to complete the research, development, prototype testing, and significant commercial integration of a new technology. As a consequence, even if the low growth estimate for electricity use could be justified, it would probably be imprudent to delay research and development on the advanced options. On the other hand, it is judicious to formulate an R&D plan that would help utilities meet potential electricity needs in the upper end of the range of electricity requirements, particularly when the projected high growth rate is lower than historical experience.

An electricity research and development program must also achieve balance both in the timing of technology development and in program emphasis. To maximize the timing emphasis of its programs and to closely complement the longer term planning emphasis of the governmental energy research, EPRI places 50 percent of its funding in the near-term research that has significance before 1985, and 40 to 45 percent of its budget is invested in programs that would expect results in the 1985 to 2000 period.

It is believed that only through such a plausible, prudent, balanced, and flexible R&D program can a nation's electric utilities, as well as other energy industries and the government, effectively cope with the future uncertainties and meet the forthcoming energy challenges.

### Foot Notes

1. Preliminary information of the report of the Supply and Demand Committee, Independent Petroleum Association of America, Washington, D.C.
2. EEI Pocketbook of Electric Utility Statistics, p. 6 (1977), Edison Electric Institute, New York.
3. Electrical Output, p. 7, 45 (1978), Edison Electric Institute, New York.
4. Annual Summary of Cost and Quality of Electric Utility Plant Fuels, p. 7 (1976), Bureau of Power, Federal Power Commission, Wash., D.C.
5. Weekly Coal Report in Monthly Energy Review, p. 28 (Oct. 1977), Dept. of Energy EIAE Information Report NTISUB/C/127-10.
6. U.S. Central Station Nuclear Power Plants, 1976, ERDA 77-125, pp. 20-21 (1976), U.S. Govt. Printing Office, Wash., D.C.
7. Evaluation of Phase 2 Conceptual Designs and Implementation Assessment Resulting from the Energy Conversion Alternatives Study, NASA Lewis Center, Cleveland, Ohio (1977).
8. Overcoming Obstacles—Energy Research and Development by W. Esselman, presented to the American Nuclear Society (April 1976).
9. Planning for Uncertainties by W. Esselman, presented to the American Chemical Society (August 1977).

### Literature Cited

- Dupree, W. (1976): Energy Perspectives 2. U.S. Dept. of Interior, U.S. Govt. Printing Office, Wash., D.C., pp. 54-77, 136.

- Esselman, Walter H. and Yu, Oliver S. (1978): Planning Electricity R & D Alternatives. In Proc. Nat'l Symp. on Critical and Strategic Materials, American Chemical Society.
- Loth, R. (1977): Coal Fired Power Plants Capital Cost Estimates. Electric Power Research Institute, Palo Alto, Calif.
- Manne, Alan (1976): ETA: A Model for Energy Technology Assessment. The Bell J. Economics 7, 379-406.
- Rudasill, C. L. (1977): Coal and Nuclear Generating Costs. Electric Power Research Institute Special Report EPRI PS-455-SR, Palo Alto, Calif.
- Smith, C. (1976): Efficient Electricity Use. Electric Power Research Institute, Palo Alto, Calif.
- Starr, C. (1976): Electricity Needs to the Year 2000 as Related to Employment, Income and Conservation, p. 2. In Energy Demand, Conservation Potential and Probable Lifestyle Changes, House Committee on Science and Technology, Wash., D.C.
- Starr, C. (1977): Energy Planning—A Nation at Risk. Presented before the Subcommittee on Advanced Energy Technologies and Energy Conservation, Research, Development, and Demonstration, Publication #90 (1977). ERDA Authorization, Part 6, Fiscal Year 1977.



# Phytomass Budgets for the Dismal Swamp Ecosystem

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**Abstract**—The Great Dismal Swamp is a heterogeneous ecosystem as a result of various human disturbances. We studied the phytomass distribution in four community types in the swamp: two with representative predisturbance dominants [Atlantic white cedar (*Chamaecyparis thyoides* (L.) BSP.) and bald cypress (*Taxodium distichum* (L.) Richard)] and two with representative post-disturbance dominants [mixed hardwoods and red maple (*Acer rubrum* L.)—gum (*Nyssa* spp.)]. The cedar community had the greatest quantity of tree leaf phytomass ( $10,830 \text{ kg ha}^{-1}$ ), shrub phytomass ( $1852 \text{ kg ha}^{-1}$ ), and woody litter ( $50,147 \text{ kg ha}^{-1}$ ). The cypress community had the largest standing crop of woody phytomass in the tree stratum ( $339,035 \text{ kg ha}^{-1}$ ). Most of the below-ground phytomass was located in the top 30 cm of soil, with the greatest quantities in the mixed hardwood stand ( $30,970 \text{ kg ha}^{-1}$ , excluding main rootstocks). Leaf litter accumulations were smallest in the stands most extensively flooded, maple-gum and cypress, possibly indicating greater decomposition rates in these two communities.

## Introduction

The Great Dismal Swamp is a heterogeneous ecosystem as a result of various human disturbances. A few areas in the swamp are occupied by regrowth communities with dominants which are representative of the predisturbance forests. However, most of the swamp is occupied by regrowth vegetation atypical of the predisturbance swamp. Future management decisions may include plans to encourage the reestablishment of the predisturbance communities. Information on the ecological dynamics of these

communities (e.g. reproductive requirements of the major species and nutrient cycling dynamics) will be required for formulating management plans. Few quantitative studies of the Dismal Swamp's ecology have been reported.

The major objective of this study was to obtain baseline information on phytomass distribution in four community types in the Dismal Swamp—two with representative predisturbance dominants and two with representative postdisturbance dominants. These data provide a foundation for studies of community dynamics and for comparisons of communities. Above-ground phytomass, below-ground phytomass, and surface litter were qualitatively and quantitatively evaluated in each of the four communities.

## Description of Study Area

The Great Dismal Swamp is an 85,000-ha, forested, peat bog located in southeastern Virginia and northeastern North Carolina. The soils are highly organic and acidic mucky peats with peat deposits ranging in depth from a few centimeters to over four meters (Henry, 1970). Under the peat deposits are clays which cause the poor drainage and maintain the area as a swamp. Canal construction and water use in areas surrounding the swamp have resulted in the lowering of the water table, and an evident drying trend is in progress. Flooding is strongly seasonal, with standing water occurring primarily during the winter and spring months. Flooding infrequently occurs during the summer following heavy rains. The geological history of the Dismal Swamp is described by Whitehead (1972).

Intensive logging, clearing, canal digging, and peat fires have altered the species composition and ecology of the area extensively (Dean, 1969; Berkeley and Berkeley, 1976). The precolonial area of the swamp is estimated to have been 202,350 ha. The vegetation was formerly dominated by bald cypress (*Taxodium distichum* (L.) Richard) and gum (*Nyssa* spp.) with scattered stands of Atlantic white cedar (*Chamaecyparis thyoides* (L.) BSP.). Once removed, the bald cypress and Atlantic white cedar have not regenerated. Hardwoods have evidently outcompeted cypress for light since cypress is reproducing only along the drainage canals. White cedar has been reported to be fire maintained (Collins et al., 1964), thus fire control, in addition to logging, may be responsible for the decline of cedar in the Dismal Swamp. Competition from hardwood saplings may prevent cedar from germinating and developing. Grigal and Oh-

mann (1975) have suggested that deer and rabbit browsing may restrict white cedar (*Thuja occidentalis* L.) reproduction in Minnesota forests. Red maple (*Acer rubrum* L.) and gum (*Nyssa* spp.) have most commonly replaced bald cypress and white cedar. In a few drier areas mixed oak (*Quercus* spp.) communities have developed.

The Dismal Swamp ecosystem is quite heterogeneous as a result of varied soils, depths of peat, degrees of flooding, treatment history, and vegetative composition. Therefore, four different community types were selected for this study. Two were dominated by predisturbance vegetation types—a bald cypress and an Atlantic white cedar community, and two were dominated by postdisturbance vegetation types—a red maple-gum and a mixed hardwood community. All four communities are regrowth stands on previously logged sites. The cypress stand is the most extensively flooded of the four, primarily because of the high clay content of the soil near the surface. The cedar stand is infrequently flooded, but frequently has saturated soils since it is the only community of the four with peat deposits. The white cedar appears to be dying as a result of natural senescence, and the stand is characterized by large amounts of woody litter and fallen trees. The maple-gum stand is extensively flooded, but the water is not as deep nor does it remain as long as in the cypress stand. The mixed hardwood stand is rarely flooded. Detailed descriptions of the vegetation of these four communities can be found in Dabel and Day (1977).

## Methods

Above-ground phytomass was determined for each of the four communities. Ten 10 × 10 m quadrats were located randomly along two transects in each stand during the summer of 1975, and within each plot all trees ≥2.54-cm diameter at breast height (dbh) were tallied by species and dbh. A 4 × 4 m quadrat was located in a corner of each 10 × 10 plot, and trees <2.54-cm dbh and ≥0.3 m tall were tallied by species and diameter at ground level. Plants <0.3-m tall were harvested from one nested 1-m<sup>2</sup> quadrat in each 10 × 10 m quadrat and returned to the lab, oven-dried at 70°C, and weighed. Leaf and wood phytomass of plants ≥0.3-m tall were estimated from regression equations of the general form  $\log_{10} \text{ dry weight} = A + B \log_{10} \text{ diameter}$ , as reported in Dabel and Day (1977). Separate equations were used for leaves, boles, and branches and for hardwoods ≥2.54-cm dbh, hardwoods <2.54-cm dbh, Atlantic white cedar, and bald cypress.

Below-ground phytomass was determined during the summer of 1977 in each community; however, main rootstocks of the trees were excluded from the measurements. Eight 0.5 × 0.5 m quadrats were positioned in a stratified random manner in each stand, with no plot located closer than 60 cm from the nearest tree base. McGinty (1976) used 60 cm from a tree base as the minimal distance which could be used to insure the sampling of roots from several plants. The quadrats were excavated in 5-cm increments to a

TABLE 1

Above-ground phytomass in units of kg ha<sup>-1</sup> oven dry weight. Error terms are 1 S.E. Only the three species with the greatest total phytomass per site are listed.

Prominent Species	Plants ≥ 2.5 cm dbh		Plants < 2.5 cm dbh ≥ 0.3 m tall		Plants < 0.3 m tall
	Leaf	Wood	Leaf	Wood	Leaf
<b>Cedar Stand</b>					
<i>Chamaecyparis thyoides</i>	7250 ± 1523	95,919 ± 20,204			
<i>Nyssa sylvatica</i>	2089 ± 263	65,524 ± 8404			
<i>Acer rubrum</i>	1311 ± 258	41,688 ± 8326	<1	<1	
Others	180	4605	361	1489	
Total	10,830 ± 1313	207,736 ± 14,848	362 ± 51	1490 ± 221	30 ± 8
<b>Cypress Stand</b>					
<i>Taxodium distichum</i>	1121 ± 235	171,976 ± 46,073			
<i>Acer rubrum</i>	1638 ± 960	60,323 ± 37,885	7 ± 3	19 ± 1	
<i>Nyssa sylvatica</i>	1423 ± 497	48,550 ± 17,563			
Others	1806	58,186	9	28	
Total	5988 ± 1360	339,035 ± 55,435	16 ± 7	47 ± 23	178 ± 33
<b>Mixed Hardwood Stand</b>					
<i>Quercus laurifolia</i>	1630 ± 1004	62,250 ± 38,420			
<i>Quercus alba</i>	847 ± 544	32,476 ± 21,074			
<i>Liquidambar styraciflua</i>	734 ± 297	24,737 ± 10,121			
Others	2018	68,883	116 ± 42	687 ± 283	
Total	5229 ± 1179	188,346 ± 42,790	116 ± 42	687 ± 283	188 ± 68
<b>Maple-Gum Stand</b>					
<i>Nyssa aquatica</i>	2685 ± 697	88,764 ± 24,223			
<i>Acer rubrum</i>	1921 ± 554	62,209 ± 20,755	35 ± 15	106 ± 73	
<i>Nyssa sylvatica</i>	968 ± 324	31,463 ± 10,760	1 ± 0.3	1 ± 1	
Others	236	6809	94	421	
Total	5810 ± 733	189,245 ± 27,019	130 ± 57	528 ± 25	26 ± 9



depth of 60 cm. Large roots were sorted out, and smaller roots were then separated by flotation and by washing the soil through a sieve. The roots were separated by diameter into several size classes, oven-dried at 70°C and weighed. No attempt was made to separate dead and living roots.

TABLE 2

*Below-ground phytomass in units of kg ha<sup>-1</sup> oven dry weight. Error terms are 1 S.E. Main rootstocks are not included.*

CEDAR STAND				
Soil Depth (cm)	Root Diameter (cm)			total
	<1	1-2	>2	
0-10	6913 ± 738	1606 ± 772	393 ± 285	8911 ± 1021
10-20	1586 ± 235	1022 ± 322	952 ± 737	3559 ± 867
20-30	907 ± 185	268 ± 77	1046 ± 771	2221 ± 813
30-40	672 ± 152	145 ± 53	469 ± 415	1286 ± 448
40-50	548 ± 115	54 ± 30	829 ± 346	1431 ± 418
50-60	487 ± 106	51 ± 27	93 ± 93	630 ± 127
Total	11,113 ± 800	3145 ± 1090	3781 ± 1549	18,038 ± 1796

CYPRESS STAND				
Soil Depth (cm)	Root Diameter (cm)			total
	<1	1-2	>2	
0-10	3691 ± 469	1863 ± 944	732 ± 532	6286 ± 844
10-20	1951 ± 400	713 ± 214	737 ± 301	3401 ± 521
20-30	1316 ± 303	417 ± 88	174 ± 83	1907 ± 321
30-40	734 ± 103	358 ± 132	374 ± 358	1466 ± 344
40-50	628 ± 150	240 ± 130	688 ± 460	1555 ± 529
50-60	530 ± 105	83 ± 75	82 ± 82	695 ± 143
Total	8850 ± 1209	3674 ± 879	2786 ± 1082	15,310 ± 988

MAPLE-GUM STAND				
Soil Depth (cm)	Root Diameter (cm)			total
	<1	1-2	>2	
0-10	3333 ± 625	897 ± 458	438 ± 286	4668 ± 1264
10-20	1741 ± 292	603 ± 238	1372 ± 1006	3716 ± 1384
20-30	858 ± 96	170 ± 76	342 ± 227	1366 ± 305
30-40	675 ± 138	313 ± 184	46 ± 33	1034 ± 298
40-50	523 ± 93	197 ± 70	27 ± 18	747 ± 147
50-60	484 ± 71	176 ± 76	27 ± 23	686 ± 156
Total	7608 ± 687	2356 ± 639	2251 ± 1214	12,216 ± 1763

MIXED HARDWOOD STAND				
Soil Depth (cm)	Root Diameter (cm)			total
	<1	1-2	>2	
0-10	8288 ± 778	2462 ± 637	3195 ± 1030	13,945 ± 1941
10-20	4641 ± 703	2258 ± 704	3723 ± 1526	10,622 ± 2199
20-30	1955 ± 334	414 ± 131	1008 ± 1008	3376 ± 811
30-40	1488 ± 381	41 ± 38	3 ± 3	1532 ± 395
40-50	991 ± 159	25 ± 22	0	1016 ± 173
50-60	477 ± 87	0	3 ± 3	480 ± 85
Total	17,839 ± 1441	5200 ± 769	7931 ± 1901	30,970 ± 3438

Woody litter with a central diameter >2 cm was sampled during the summer of 1976 in the 10 × 10 m quadrats described above. Most of the woody litter >2 cm in diameter, which included fallen tree boles, was weighed wet in the field, and subsamples from each quadrat were taken back to the lab for determination of wet weight to dry weight conversion factors. Wet weights were then converted to oven dry weights. Details on the methods used are described in Day (1979). During the summer of 1975, woody litter ≤2 cm in diameter was harvested in the 4 × 4 m quadrats described above, returned to the lab, oven dried at 70°C, and weighed.

Leaf litter was removed from ten 0.5 × 0.5 m quadrats randomly positioned in each community in December 1976. The cedar community was sampled in January 1977 because road conditions made the area inaccessible during December. The leaf litter was separated into the 01 and 02 layers, returned to the lab, oven dried at 70°C, and weighed. The January sample from the cedar stand included only the 01 layer as the 02 layer and soil were frozen. An estimate of the January 02 layer was made based on the April 02 standing crop. The January value was taken as 133.33 percent of the April value as this was the approximate relationship in the other communities.

The Student t-test was used to test for significant differences between mean phytomass values for the four communities.

## Results and Discussion

The above-ground phytomass data are reported in Table 1. The dominant species based on total phytomass in each community were white cedar, black gum (*Nyssa sylvatica* Marshall), and red maple in the cedar stand; bald cypress, red maple, and black gum in the cypress stand; laurel oak (*Quercus laurifolia* Michaux), white oak (*Quercus alba* L.), and sweetgum (*Liquidambar styraciflua* L.) in the mixed hardwood stand; and water gum (*Nyssa aquatica* L.), red maple, and black gum in the maple-gum stand. Red maple and black gum were the only species common to all four communities. These two species are ubiquitous in their distribution and are expected to occur over a broad range of environmental conditions.

The rank order of sites based on leaf phytomass in the tree stratum was cedar > cypress > mixed hardwood > maple-gum. Leaf phytomass in the cedar stand (10,830 kg ha<sup>-1</sup>) was notably greater than in the other three stands. The value for the cedar stand was an overestimate as a result of the techniques of harvesting Atlantic white cedar. It is very difficult, if not impossible, to effectively separate cedar leaf tissue from twig tissue. The leaves are closely appressed to the stem and cannot be efficiently removed. Thus, the leaf material harvested for the regression analysis actually contained woody tissue, and the cedar leaf phytomass is not comparable to the values for the other sites.

The rank order of stands based on woody phytomass differed from the ranking based on leaf phytomass by the reversed positions of the cedar and cypress stands. The cypress community had the greatest woody phytomass (339,035 kg ha<sup>-1</sup>) and was signifi-

TABLE 3  
Litter standing crops in units of  $\text{kg ha}^{-1}$  oven dry weight. Error terms are 1 S.E.  
Leaf litter estimates are peak values based on December and January samples.

Litter Type	Cedar Stand	Cypress Stand	Mixed Hardwood Stand	Maple-Gum Stand
Woody, $\leq 2$ cm diameter	2744 $\pm$ 156	1738 $\pm$ 388	1044 $\pm$ 150	1344 $\pm$ 113
Woody, $> 2$ cm diameter	47,403 $\pm$ 12,335	43,650 $\pm$ 8,433	7384 $\pm$ 1739	25,423 $\pm$ 9983
Total woody	50,147	45,388	8428	26,767
01 leaf	4028 $\pm$ 210	4800 $\pm$ 344	5484 $\pm$ 199	5112 $\pm$ 263
02 leaf	6027 <sup>a</sup>	4124 $\pm$ 422	7836 $\pm$ 664	3192 $\pm$ 346
Total leaf	10,055	8924 $\pm$ 56	13,320 $\pm$ 58	8304 $\pm$ 40

<sup>a</sup> Not sampled because 02 was frozen. Estimated as 133.33% of April 02 standing crop.

cantly different ( $P < 0.05$ ) from each of the other three stands. The cypress and cedar stands were apparently the oldest of the four, as evidenced by several tree increment cores which have been taken, and these communities have accumulated the greatest above-ground phytomass (leaf and wood).

The cedar stand had the largest shrub phytomass, followed by the mixed hardwood, maple-gum, and cypress stands respectively. Significant differences ( $P < 0.05$ ) were found between the cedar stand and each of the other three and between the cypress stand and both broadleaf deciduous stands. The cedar stand was in a transitional state as a result of large numbers of white cedar trees dying and hardwood saplings replacing them; thus, canopy openings allowed greater development of the shrub layer. Extensive flooding in the cypress community may have prevented the development of a shrub layer. The herb layer was relatively sparse in all four communities.

The below-ground phytomass data are reported in Table 2. Total root mass steadily decreased with increasing soil depth. Most of the roots were found in the top 30 cm of soil: 76 percent of the total root mass in the cypress stand, 80 percent in the maple-gum, 81 percent in the cedar, and 90 percent in the mixed hardwood. The bulk of the roots were located in the soil region where nutrients are being released through decomposition of organic matter and litter and are entering the soil in precipitation and throughfall. There is no apparent pattern of distribution of roots  $> 2$  cm in diameter. These structures are essentially nonfunctional in nutrient uptake but are important as support for the trees. Most of the below-ground phytomass consisted of roots  $< 1$  cm in diameter with the percent contribution to this size category being approximately the same in all four communities: 58 percent in the cypress and mixed hardwood stands and 62 percent in the cedar and maple-gum stands. Therefore, excluding the main rootstocks, most of the root mass is accounted for by roots functionally active in nutrient uptake in the most strategic regions of the soil.

The rank order of communities based on total root phytomass was mixed hardwood  $>$  cedar  $>$  cypress  $>$  maple-gum. The mixed hardwood stand (30,970  $\text{kg ha}^{-1}$ ) was significantly different ( $P < 0.01$ ) from each of the other three, and the cedar stand was significantly different ( $P < 0.05$ ) from the maple-gum. The larger amount of roots in the mixed hardwood and cedar communities may be explained by the greater quantity of shrubs and herbaceous plants in these two

stands. Also, the unflooded soils (mixed hardwood and cedar stands) had greater root masses than the flooded soils (cypress and maple-gum). Anaerobic soil conditions may retard root production, and the higher clay content of the flooded soils probably inhibited root growth also.

Litter standing crop data are listed in Table 3. Woody litter, small and large, varied between communities with cedar  $>$  cypress  $>$  maple-gum  $>$  mixed hardwood. The quantity of large boles and branches differed significantly ( $P < 0.01$ ) between the cedar and cypress communities and the mixed hardwood community. The amount of small woody litter in the cedar community was significantly different from each of the other three ( $P < 0.01$  for maple-gum and mixed hardwood and  $P < 0.05$  for cypress). The cedar community had two to five times as much woody litter (50,147  $\text{kg ha}^{-1}$ ) as the two broadleaf deciduous communities. The bulk of the woody litter in the cedar community consisted of dead white cedar trees, white cedar branches which had been self-pruned, and large quantities of dead cat brier vines (*Smilax* spp.). The large accumulations of woody litter in the cedar and cypress stands may be partially explained by the decay resistance of bald cypress and white cedar wood. The accumulation of decay resistant wood may affect soil nutrient relations.

The ranking of communities based on quantity of 01 leaf litter in December was the reverse of that for woody litter: mixed hardwood  $>$  maple-gum  $>$  cypress  $>$  cedar. The cedar stand was significantly different ( $P < 0.01$ ) from both broadleaf deciduous communities. The amount of 02 leaf litter in the mixed hardwood community was significantly different ( $P < 0.01$ ) from both the cypress and maple-gum stands. Total leaf litter (01 + 02) varied significantly ( $P < 0.01$ ) between the maple-gum, cypress, and mixed hardwood communities. The smallest total leaf litter pools occurred in the flooded communities (cypress and maple-gum), and we suspect that leaf decomposition rates may be higher in these stands as a result of the seasonal flooding. Bell and Sipp (1975) reported that matting of litter by flood waters slows drying and thus promotes decomposition.

Total phytomass budgets for the four communities studied are presented in Table 4. Below-ground phytomass as a percentage of above-ground phytomass was calculated from these data to evaluate the contribution of root mass (excluding main rootstocks) to the community in relation to the amount of above-ground phytomass. The rank order of commu-



TABLE 4

Total phytomass budgets in units of  $\text{kg ha}^{-1}$  oven dry weight.  
Below-ground phytomass excludes main rootstocks.

	Cedar Stand	Cypress Stand	Mixed Hardwood Stand	Maple- Gum Stand
Leaf phytomass	11,222	6182	5533	5966
Wood phytomass	209,226	339,082	189,033	189,773
Total above- ground phyto- mass	220,448	345,264	194,566	195,739
Below-ground phytomass	18,038	15,310	30,970	12,216
leaf litter	10,055	8924	13,320	8304
wood litter	50,147	45,388	8428	26,767
total litter	60,202	54,312	21,748	35,071

nities based on this percentage was mixed hardwood (15.9%) > cedar (8.2%) > maple-gum (6.2%) > cypress (4.4%). These results support the previous suggestion that development of the fine root system is not as great in the flooded communities. The relationship between litter accumulations and above-ground phytomass was evaluated by computing total litter as a percent of above-ground phytomass. The rank order of communities based on this percentage was cedar (27.3%) > maple-gum (17.9%) > cypress (15.7%) > mixed hardwood (11.8%). This progression is probably the result of a complex set of factors. The cedar stand probably had more litter per unit phytomass because decay resistant wood from dying white cedar trees was accumulating, decomposition was not favored by flood conditions, and the soils were very acid. Decomposition may have been favored in the maple-gum stand by flood conditions, and there was less accumulation of dead tree boles. Despite large accumulations of tree boles in the cypress community, the stand ranked third in litter accumulation per unit of above-ground phytomass as a result of possible high decomposition rates produced by seasonal flood conditions. The mixed hardwood community had the greatest amount of leaf litter accumulation but very little wood litter.

The Dismal Swamp communities appear to be relatively productive compared to some other swamps. Reiners (1972) reported a northern white cedar swamp in Minnesota to have  $159,600 \text{ kg ha}^{-1}$  above-ground phytomass, compared to  $220,448 \text{ kg ha}^{-1}$  in the Dismal Swamp cedar community. The above-ground phytomass in the Okefenokee cypress swamp has been reported to be  $306,590 \text{ kg ha}^{-1}$  (Schlesinger, 1978), compared to  $345,264 \text{ kg ha}^{-1}$  in the Dismal Swamp cypress community. Litter accumulations in

the Dismal Swamp were also relatively large, as Reiners (1972) reported  $11,093 \text{ kg ha}^{-1}$  litter (excluding large boles and branches) in the northern white cedar swamp in Minnesota and Bell and Sipp (1975) reported  $9900 \text{ kg ha}^{-1}$  in an Illinois flood plain oak forest.

The results of the present study provide a quantitative base for research on functional features (e.g. nutrient cycling dynamics) of four community types in the Dismal Swamp. More complete knowledge of the ecological relationships in these community types will allow intelligent decisions to be made concerning possible recovery of the Dismal Swamp ecosystem.

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### Literature Cited

- Bell, D. T. and Sipp, S. K. (1975): The Litter Stratum in the Streamside Forest Ecosystem. *Oikos* **26**, 391-397.
- Berkeley, E. and Berkeley, D. (1976): Man and the Great Dismal. *Va. J. Sci.* **27**, 141-171.
- Collins, E. A.; Monk, C. D. and Spielman, R. H. (1964): White-Cedar Stands in Northern Florida. *Quart. J. Florida Acad. Sci.* **27**, 107-110.
- Dabel, C. V. and Day, F. P. (1977): Structural Comparisons of Four Plant Communities in the Great Dismal Swamp, Virginia. *Bull. Torrey Bot. Club* **104**, 352-360.
- Day, F. P. (1979): Litter Accumulation in Four Plant Communities in the Dismal Swamp, Virginia. *Am Mid. Nat.*, in press.
- Dean, G. W. (1969): Forests and Forestry in the Dismal Swamp. *Va. J. Sci.* **20**, 166-173.
- Grigal, D. F. and Ohmann, L. F. (1975): Classification, Description, and Dynamics of Upland Plant Communities Within a Minnesota Wilderness Area. *Ecol. Monogr.* **45**, 389-407.
- Henry, E. F. (1970): Soils of the Dismal Swamp of Virginia. *Va. J. Sci.* **21**, 41-46.
- McGinty, D. T. (1976): Comparative Root and Soil Dynamics on a White Pine Watershed and in the Hardwood Forest in the Coweeta Basin. Ph.D. Dissertation, 110 pp., Univ. of Georgia.
- Reiners, W. A. (1972): Structure and Energetics of Three Minnesota Forests. *Ecol. Monogr.* **42**, 71-94.
- Schlesinger, W. H. (1978): Community Structure Dynamics and Nutrient Cycling in the Okefenokee Cypress Swamp-Forest. *Ecol. Monogr.* **48**, 43-65.
- Whitehead, D. R. (1972): Developmental and Environmental History of the Dismal Swamp. *Ecol. Monogr.* **42**, 301-315.

# Disruptive Selection for Oviposition Site in *Tribolium Castaneum*

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**Abstract**—Disruptive selection on preference for oviposition site was carried out with *Tribolium castaneum*. Population cages contained either 50 or 200 beetles on each side and were subjected to either 40 or 80 percent selective pressure. Migration was allowed between the two sides of each population cage. With successive generations of selection, there was a significant decrease in the migration rate in the experimental populations as compared with the control populations. Of four criteria used to evaluate the effect of selection on oviposition site, only the analysis of the proportion of parental adults in the selectively favored medium suggested a positive response to selection. Density regulation proved to be very important in the population cage experiments and prevented the detection of any effect of selection on the proportion of pupae in the favored medium.

## Introduction

Disruptive selection, selection favoring more than one optimal phenotype, can result in increased genetic variability, establishment of polymorphisms, and divergence leading to reproductive isolation. Reproductive isolation, the most controversial outcome of disruptive selection, has been demonstrated in the laboratory only a few times. Thoday and Gibson (1962) reported rapid development of reproductive isolation in response to disruptive selection for sternopleural chaetae number in *Drosophila melanogaster*. Attempts to confirm their results have not been successful (Scharloo et al., 1967; Chabora, 1968; Barker and Cummins, 1969). Robertson (1970), Thoday and Gibson (1970), Scharloo (1971) and Thoday and Gibson (1971) have discussed possible reasons for the failure to confirm Thoday and Gibson's 1962 results. Disruptive selection on some behavioral traits has been successful in producing divergence and incipient reproductive isolation. Coyne and Grant (1972) found evidence for isolation while selecting for vertical I-maze activity in *D. melanogaster* in a study which permitted no migration. Pimentel et al. (1967) and Soans et al. (1974) demonstrated divergence in

populations of *Musca domestica* while allowing for gene flow. The former study selected for oviposition site and the latter for rate of geotactic response.

Many questions remain unanswered concerning the importance of such factors as selective pressure, gene flow, and population size on the final outcome of disruptive selection. The experiments reported here were designed to answer the questions: "Can a regime of disruptive selection for choice of specific oviposition sites result in divergence in site preference?" and "How is the outcome of selection affected by varying selective pressures, gene flow and population sizes?"

## Materials and Methods

(i) *Synthetic population*—A synthetic population was constructed from three different wild type strains of *Tribolium castaneum* (Chicago via the University of Chicago, UPF Foundation via SUNY at Stony Brook, synthetic wild type via California State College, San Bernardino) by making all possible reciprocal crosses between the three strains for two generations. Progeny from the second generation were allowed to mate randomly for a third generation, which became the synthetic population used in the selection experiments.

(ii) *Media and standard conditions*—All beetle stocks were kept in a standard medium consisting of 5 percent brewers yeast and 95 percent whole wheat flour. The two experimental media were (1) clove medium, made of 1.5 g of ground clove spice/100 g of standard medium and (2) nutmeg medium, made of 1.5 g of nutmeg/100 g of standard medium. All stocks and experimental populations were kept in the dark in an incubator at 29°C and 70 ± 5 percent relative humidity.

(iii) *Population cages*—Population cages (Figure 1) were constructed from covered, four-chambered plastic boxes (21.3 cm × 7.0 cm × 6.0 cm, Tri-State Plastics) (Keim, 1976a). The two outermost chambers held five 50mm × 25 mm shell vials. Each vial contained eight grams of either clove or nutmeg medium. The ratio of clove:nutmeg vials depended on the selective pressure practiced in the particular experiment. In disruptive selection cages, adhesive tape "ladders" were attached to the walls of the partitions and to the sides of the vials to allow for movement of the beetles from one chamber to another and from vial to vial.



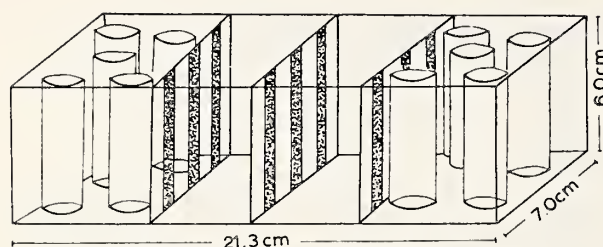


FIG 1—Population cage with media-containing vials.

(iv) *Experimental design*—Two population sizes, 50 and 200, and 2 selective pressures, 40 and 80 percent, were employed. For populations under 40 percent selective pressure, the clove side of the cage contained clove and nutmeg vials in a ratio of 3:2, and the nutmeg side contained a ratio of 3 nutmeg : 2 clove vials. On the clove side, only progeny arising from the three clove vials could contribute to the gene pool of the next generation. On the nutmeg side, only progeny from the nutmeg vials were saved.

The population cages where 80 percent selective pressure was practiced contained one clove vial and four nutmeg vials on the clove side and one nutmeg vial and four clove vials on the nutmeg side. Only progeny from the single clove vial on the clove side or from the nutmeg vial on the nutmeg side were selected. Control populations were identical to and handled in the same way as the corresponding experimental cages except that no selection for clove or nutmeg preference was practiced. Each selective regime was carried out in quadruplicate, and controls for each regime in duplicate.

(v) *General selection procedure*—The following procedure (using a population size of 50 as an example) was followed to begin each population: The beetles were sexed as pupae and allowed to mature into adults. Twenty-five males and 25 females were marked with a small dot of blue Testor's enamel paint and introduced into the clove side of the population cage. The same number of beetles were marked with yellow paint and introduced into the nutmeg side. The cage was then put in the incubator and kept under standard conditions. After 15 days the parental adults were removed and censused according to their location and markings. This information was used to measure the amount of migration. The remaining contents (flour, eggs, and larvae) were returned to the incubator. After an additional 15 days, the pupae in each vial were counted (day 30). A second count was made five days later (day 35) and added to the first count to increase sample size. The pupae from the selectively favored vials were sexed, held for maturation to adulthood, and marked with the appropriate paint. Twenty-five males and 25 females representing the parents of the next generation were introduced into the designated side of the cage, which contained vials of fresh medium. The identical procedure was followed for the populations of 200 beetles, except that 100 males and 100 females were introduced each time.

(vi) *Density experiments*—Since early data suggested that density regulation might be important in

the populations, separate experiments were carried out to determine the effect of density of adults on the number of pupae in a given vial. Adult beetles were introduced into vials containing eight g of either clove or nutmeg medium. Densities varied from 2 to 200 beetles per vial with 2 replicates for each density (male to female ratio, 1:1). The vials were kept under standard conditions. Parents were removed after 15 days; pupae were counted after an additional 15 days and again 5 days later.

(vii) *Preference tests*—Several methods were used to determine preferences of the beetles in the synthetic population and in the cage experiments for either clove or nutmeg medium.

Initially, adult location and number of progeny were used. Beetles from the original synthetic population were sexed as pupae and held until the adults were at least three days old. Five pairs were introduced into a chamber containing one clove vial and one nutmeg vial, each with eight g of appropriate medium. After 24 hours their locations were noted, the adults were removed from the chamber, and the contents were returned to the incubator for 20 days. At day 20 larvae and pupae were counted.

In the cage experiments, the number of pupae arising in selectively favored medium was to be the primary indicator of development of preference. However, the density effects noted in the course of the work suggested that pupae numbers might not be a good criterion for detecting the effects of selection. Therefore, direct egg counts were added as an additional preference test. Egg counts were made on the original synthetic population, all experimental populations, and their corresponding controls.

The procedure for counting eggs was as follows: ten male and ten female adults from the appropriate population were introduced into a chamber containing two vials. Progeny from the final generations were used in the case of experimental and control populations. One vial contained 2 g of a mixture of clove medium plus neutral red dye (5 g neutral red/100 g flour mixture), the other, nutmeg medium plus neutral red. The neutral red dye was added to aid in the identification of the eggs (Ho, 1967). The chambers were incubated under standard conditions for 48 hours; eggs were counted, and the specific locations of adults were noted.

## Results

(i) *Initial preference tests*—All preference tests carried out on the synthetic population indicated that the beetles had an initial preference for nutmeg medium. The preference for nutmeg as indicated by counts of pupae was highly significant ( $G = 132.80$ ;  $P < 0.001$  where  $G$  = a statistic used to determine the degree of agreement between observed and expected frequencies and  $P$  = probability). The corresponding data on adult location in the experiment followed the same pattern, with a highly significant preference for nutmeg ( $G = 6.29$ ;  $P < 0.025$ ). (See Keim, 1976b, Tables 1 and 2 for actual data.)

Egg counts for the synthetic population were made at the same time as those for experimental populations. The beetles used were obtained from mass

cultures of the synthetic population reared in standard medium. There was a highly significant preference for the nutmeg medium as the site of oviposition ( $G = 11.97$ ;  $P < 0.001$ ). These results are consistent with earlier tests and indicate that preference for nutmeg had not changed in the original synthetic population during the course of the population cage experiments. Also, the regression of the proportion of eggs laid in a given vial on the proportion of adults in that vial at the time of the egg counts was significant ( $b = +0.2821$ ;  $t = 2.9162$ ;  $P < 0.001$  where  $b$  = regression coefficient and  $t$  = statistic to test the significance of regression coefficient). (See Keim, 1976b, Table 3 for actual data.)

(ii) *Migration*—A regression analysis was carried out to detect changes in the number of immigrants per generation (Table 1). Calculations were made using the mean of replicates for each experimental regime. A sign test of regression coefficients, comparing experimental and corresponding control populations, demonstrated a significant decline in the amount of migration in the experimentals ( $8 - : 0 +$ ;  $P < 0.05$ ). (See Keim, 1976b, Appendix A for actual data.)

A multiway G analysis was used to look for possible interactions between population cage conditions (population size and selective pressure), migration rates and generation (initial vs. final). Analyses were

made on complete and partitioned data. When data from all populations were used, all but one of the two- and three-way interactions were significant. Analyses of data partitioned with respect to population size and selective pressure did not suggest a clear pattern of response to selection but rather considerable heterogeneity in the response of different populations.

In summary, there was a decrease in the migration rate in the experimental populations as compared with the controls. Great variability was apparent in the responses of different populations to selection, both in the pattern of change in migration and in the final level of migration in each population.

(iii) *Density*—The results of these experiments show changes that occur in the number of progeny in eight g of flour as the number of parents is increased (Figure 2). At densities from two to eight parents per vial, there is a rapid rise in the number of progeny. The number of progeny then levels off until the number of parents exceeds 100. Then there is a significant decrease in productivity at the 2 highest densities, 150 and 200. These densities approximate those possible in the population cages. If density factors are concealing any effect of selection, the proportion of pupae in each medium may not be a good preference criterion for oviposition site. If a vial were strongly favored, and many beetles responded to selection by

TABLE 1  
*Effect of disruptive selection on migration of Tribolium castaneum; Regression of the number of immigrants on the generation number (using means of replicates)*

POPULATIONS A:B:C	df	b	CLOVE SIDE t	P	b	NUTMEG SIDE t	P
50:0:1							
50:0:2	12	+0.3473	1.1825	.10-.05	-0.3604	1.6985	0.2-0.1
50:0:3							
50:0:4	12	+0.1088	0.3928	0.8-0.5	+0.0516	0.1532	0.9-0.8
50:40:2							
50:40:3							
50:40:4	11	-0.0465	0.2107	0.9-0.8	-0.6566	2.9765	.02-.01
50:80:1							
50:80:2							
50:80:3							
50:80:4	11	-0.1054	0.5389	0.8-0.5	-0.3746	0.9311	0.5-0.4
200:0:1							
200:0:2	11	-0.0742	0.0693	1.0-0.9	+0.0082	0.0105	1.0-0.9
200:0:3							
200:0:4	10	-1.1626	0.9934	0.4-0.2	-2.8479	1.9072	0.1-.05
200:40:1							
200:40:2							
200:40:3							
200:40:4	11	-0.7112	0.9938	0.4-0.2	-3.1401	5.0641	0.001
200:80:1							
200:80:2							
200:80:3							
200:80:4	9	-2.5911	2.8998	.02-.01	-6.3696	3.0317	.02-.01

A = population size

B = selective pressure

C = replicate number

df + 1 = number of generations of selection



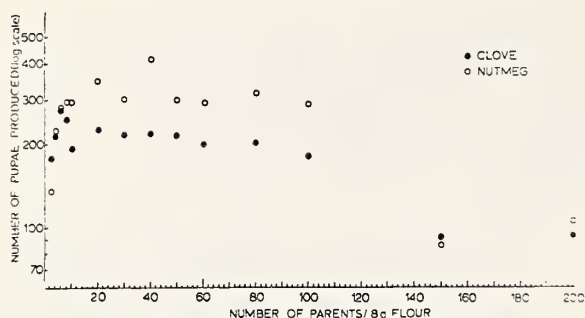


FIG. 2—Density experiment. The relationship between the number of parents (x-axis) and the number of pupae (y-axis).

laying their eggs in the vial, it might yield considerably fewer progeny due to severe crowding.

(iv) *Oviposition site*—Several kinds of data were used to evaluate the selective action on oviposition site: (1) changes in pupae proportion in favored vials from the population cages, (2) changes in parent proportion in favored vials at the time of removal from cages, (3) changes in the number of eggs laid in each medium in choice experiments, and (4) changes in the number of adults in each medium as compared with the synthetic population (for experiments involving egg counts).

The proportions of pupae in favored vials for the initial and final generations were compared by contingency  $\chi^2$  analyses. (See Keim, 1976b, Appendix C for actual data.) Significant differences between generations were seen for some populations, but the direction of change was not always predictable from the particular selection regime practiced on the population. The wide fluctuations in numbers of pupae seen from generation to generation probably reflected the density effects previously discussed. Because of the apparent density effects, it was concluded that the pupal data were not useful for detecting changes in the preference for oviposition site resulting from selection.

Since the proportion of pupae appeared to be greatly affected by density regulation, data on the location of parental adults at the time of their removal at day 15 were examined for any indications of the effects of selection on oviposition site.

Regression analyses of the proportion of parental adults on generation number for each population were carried out (Tables 2 and 3). (See Keim, 1976b, Appendix F for actual data.) Sign tests comparing the regression coefficients of the controls and their corresponding experimentals yielded six comparisons in which the regression coefficients were more positive in the experimentals than in the controls and two with coefficients more negative in the experimentals than in the controls. All the comparisons for populations of 50 were positive as were those for populations of 200 with 40 percent selective pressure. The experimentals with more negative regression coefficients were populations of 200 with 80 percent selective pressure. The  $6 + 2 -$  sign test does not indicate a statistically significant difference between the experimentals and the controls. However, it does suggest that, in the largest and most severely selected populations, the proportion of adults in a given vial is affected by crowding in the selectively favored vials. Under more favorable conditions, the disruptive selection resulted in an increase in the proportion of parental adults in the favored vials.

(v) *Counts of eggs*—A contingency  $\chi^2$  analysis was made to compare the original synthetic population and final generation of each experimental population with respect to number of eggs laid in each medium (Tables 4 and 5). (See Keim, 1976b, Appendix E for actual data.) No obvious pattern of change is detectable from these calculations. Even some of the control populations showed changes in direction of preference. In some cases, this may have been the result of adaptation of the beetles to the clove scent, but this cannot explain the results in all populations.

The controls were compared with the corresponding experimentals by a sign test using  $\chi$  (chi) values.

TABLE 2

Effect of disruptive selection on the location of parental adults of *Tribolium castaneum*; Regression of the number of parental adults (in selectively favored vials) on generation. Populations of 50.

POPULATIONS A:B:C	CLOVE SIDE			NUTMEG SIDE		
	b	t	P	b	t	P
50:0:1	-0.4769	0.9012	0.4-0.2	-0.1033	0.2275	0.9-0.5
50:0:2	+0.1209	0.2483	0.9-0.5	-1.1429	2.5578	0.05-0.02
combined	-0.2153	0.6152	0.9-0.5	-0.5754	2.2748	0.05-0.02
50:0:3	-0.1154	0.3693	0.9-0.5	-0.3077	1.2674	0.4-0.2
50:0:4	-0.3601	1.3515	0.4-0.2	-0.3006	2.5353	0.05-0.02
combined	-0.2217	1.1405	0.2-0.1	-0.3219	2.5723	0.02-0.01
50:40:1	-0.9714	0.7358	0.9-0.5	-3.8571	2.4718	0.1-0.05
50:40:2	+0.0105	0.0166	0.9	+0.4720	1.0997	0.4-0.2
50:40:3	+0.5455	0.8950	0.4-0.2	+0.1783	0.3781	0.9-0.5
50:40:4	+1.0824	2.0734	0.1-0.05	+0.2692	0.6842	0.9-0.5
combined	+0.8048	2.6619	0.02-0.01	+0.2040	0.8546	0.4-0.2
50:80:1	-0.3077	0.4544	0.9-0.5	-0.0804	0.5685	0.9-0.5
50:80:2	+0.1853	0.5632	0.9-0.5	-0.2098	1.2728	0.9-0.5
50:80:3	+0.7098	1.8973	0.1-0.05	+0.0874	0.4388	0.9-0.5
50:80:4	+0.2802	0.7484	0.5-0.4	+0.0110	0.0826	0.9
combined	+0.2411	1.3414	0.2-0.1	-0.0566	0.7188	0.5-0.4

A = population size

B = selective pressure

C = replicate number

TABLE 3

Effect of disruptive selection on the location of parental adults of *Tribolium castaneum*; Regression of the number of parental adults (in selectively favored vials) on generation. Populations of 200.

POPULATIONS A:B:C	CLOVE SIDE			NUTMEG SIDE		
	b	t	P	b	t	P
200:0:1	+1.9755	0.9799	0.4-0.2	+0.1923	0.1233	0.9
200:0:2	-0.1364	0.0645	0.9	-2.7448	1.2186	0.4-0.2
combined	+0.9196	0.6542	0.9-0.5	-1.2762	0.9768	0.4-0.2
200:0:3	+0.4650	0.6197	0.9-0.5	+0.4021	0.8842	0.4-0.2
200:0:4	+1.1364	1.3746	0.2-0.1	-0.3322	0.5750	0.9-0.5
combined	+0.8007	1.4780	0.2-0.1	+0.0350	0.0998	0.9
200:40:1	-0.4615	2.1911	0.1-0.05	-0.2203	0.1836	0.9-0.5
200:40:2	+2.6853	1.4659	0.2-0.1	-4.1189	1.9662	0.1-0.05
200:40:3	+1.5055	0.8310	0.5-0.4	+0.4890	0.3234	0.9-0.5
200:40:4	+2.5769	1.2569	0.4-0.2	-1.1748	0.6936	0.9-0.5
combined	+1.6046	1.7331	0.1-0.05	-1.0137	1.2901	0.4-0.2
200:80:1	-1.1573	1.4045	0.2-0.1	-0.4580	1.0581	0.4-0.2
200:80:2	-1.8391	1.7827	0.2-0.1	-1.2872	2.4654	0.05-0.02
200:80:3	-1.0909	1.1433	0.2-0.1	-0.8671	1.3791	0.2-0.1
200:80:4	-0.1399	0.1339	0.9-0.5	-0.7692	1.3181	0.4-0.2
combined	-0.9870	2.1392	0.1-0.05	-0.7957	3.0345	0.02-0.01

A = population size

B = selective pressure

C = replicate number

The  $\chi^2$ 's were calculated from the  $\chi^2$ 's for the combined replicates. The results indicate no overall significant change in experimental populations as a result of selection. In the disruptively selected populations, changes in the expected direction are evident in four of eight experimental regimes. No consistent pattern with respect to population size or selective pressure was evident in the egg counts.

A correlation analysis was carried out using the proportion of eggs and corresponding adult location data. Calculations were made on combined data for the final generation of all disruptively selected populations. The correlations were significant for both clove and nutmeg media (clove:  $r = +0.3993$ ,  $0.1 < P < 0.05$ ; nutmeg:  $r = +0.5654$ ,  $P < 0.01$ ). These data agree with those of the original preference tests. In a relatively uncrowded environment, the preference of adults for a given medium also reflects a preference for oviposition under these experimental conditions.

### Discussion

The present experiments suggest that disruptive selection resulted in increased preference for specific oviposition sites in all but the largest and most intensely selected populations. However, the change in preference was not statistically significant. Density factors greatly influenced the possibility of detecting a response to selection. The selection regime intensifying crowding in selectively favored vials and probably resulted in decreased numbers of progeny in these vials rather than the expected increase.

The density effects which complicate the interpretation of the results are of considerable interest. Density may affect the competitive advantage of different chromosomal inversion types of *D. pseudoobscura* (Birch, 1955) and the viabilities of different strains of *D. melanogaster* (Lewontin, 1955). Sokal and Karten (1964) demonstrated that survivorship of

different genotypes of *Tribolium castaneum* in mixed cultures was both density- and frequency-dependent. Clark's (1972) model of density-dependent selection indicated that polymorphisms could be established when density-dependent selection was combined with

TABLE 4

Egg counts of *Tribolium castaneum*; Contingency  $\chi^2$  comparing the number of eggs laid in clove and nutmeg for the synthetic population and the last generation of the experimental populations. Populations of 50.

POPULATIONS A:B:C	CLOVE SIDE		NUTMEG SIDE	
	$\chi^2$	Direction of Increase	$\chi^2$	Direction of Increase
50:0:1	0.0198	ns	11.5797**	C
50:0:2	19.1334**	N	0.0566	ns
combined	9.3999	N	5.9593*	C
50:0:3	7.1796**	C	9.5634**	N
50:0:4	1.4852	ns	3.4131	ns
combined	0.3892	ns	0.0039	ns
50:40:2	0.0007	ns	9.1817**	N
50:40:3	1.1948	ns	1.9583	ns
50:40:4	0.0072	ns	7.0987**	C
combined	0.4034	ns	1.3153	ns
50:80:1	1.3866	ns	4.6091*	N
50:80:2	1.3915	ns	0.0035	ns
50:80:3	0.9939	ns	10.7641**	N
50:80:4	1.2094	ns	0.7408	ns
combined	0.7872	ns	4.8186	N

\* indicates significance at the .05 level

\*\* indicates significance at the .01 level

ns indicates no significance

Direction of Increase: refers to the medium (clove = C; nutmeg = N) in which the number of eggs was significantly higher than the number of eggs for the synthetic population.

A = population size

B = selective pressure

C = replicate number



TABLE 5

Egg counts of *Tribolium castaneum*; Contingency  $\chi^2$  comparing the number of eggs laid in clove and nutmeg for the synthetic population and the last generation of the experimental populations.  
Populations of 200.

POPULATIONS	CLOVE SIDE	NUTMEG SIDE
A:B:C	Direction of Increase $\chi^2$	Direction of Increase $\chi^2$
200:0:1	9.1346** C	6.8255** C
200:0:2	0.4223 ns	0.0352 ns
combined	5.7429* C	3.4726 ns
200:0:3	2.9449 ns	3.4931 ns
200:0:4	10.3205** C	4.8768* C
combined	10.3127** C	7.1387** C
200:40:1	0.0144 ns	6.5612* C
200:40:2	5.6589* C	0.7142 ns
200:40:3	2.3177 ns	0.3855 ns
200:40:4	1.6022 ns	0.0268 ns
combined	0.3633 ns	3.7331 ns
200:80:1	0.0778 ns	0.2138 ns
200:80:2	6.2256* N	5.1997* N
200:80:3	28.2582** N	35.0865** N
200:80:4	0.9255 ns	1.4949 ns
combined	13.0769** N	12.3707** N

\* indicates significance at the .05 level

\*\* indicates significance at the .01 level

ns indicates no significance

Direction of Increase: refers to the medium (clove = C; nutmeg = N) in which the number of eggs was significantly higher than the number of eggs for the synthetic population.

A = population size

B = selective pressure

C = replicate number

selection for specific niches in a heterogeneous environment. In the present study, density effects appear to have masked or reduced the response to selection.

Complex interactions between different types of selection which would be expected in natural populations influence the effectiveness of disruptive selection, as do factors such as the genetic composition of the population and gene flow. Thoday and Gibson's (1962) Southacre stock had special characteristics which made possible the rapid response to selection, whereas a different stock, Buenos Aires, has not shown evidence of isolation developing after more than 60 generations of disruptive selection (Thoday and Gibson, 1970). With respect to gene flow, the greater it is, the larger the selective pressures must be to allow divergence and isolation between disruptively selected subpopulations. Gillespie (1975), while studying the relationship between migration and polymorphisms in environments with temporal and spatial variation, found that if the environment varies spatially, a decrease in migration increases the probability of polymorphisms. In the present study migration decreased as selection progressed. This decrease would be expected to enhance separation of the two subpopulations, though this was not reflected in all the data on oviposition site.

The specific results obtained in disruptive selection experiments represent complex and numerous inter-

actions between such factors as the genetic makeup of the population, selective pressure, amount of gene flow and population dynamics. Further experiments involving diverse organisms and a variety of experimental regimes will help to determine how these various factors affect differentiation in populations and to evaluate the relative importance of disruptive selection in natural populations.

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### Literature Cited

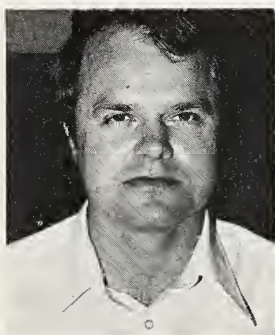
- Barker, J. S. F. and Cummins, L. J. (1969): Disruptive Selection for Sternopleural Bristle Number in *Drosophila melanogaster*. *Genetics* **61**:713-719.
- Birch, L. (1955): Selection in *Drosophila pseudoobscura* in Relation to Crowding. *Evolution* **9**:389-399.
- Chabora, A. J. (1968): Disruptive Selection for Sternopleural Chaetae Number in Various Strains of *Drosophila melanogaster*. *Am. Natur.* **102**:525-532.
- Clarke, B. (1972): Density-Dependent Selection. *Am. Natur.* **106**:1-13.
- Coyne, J. A. and Grant, B. (1972): Disruptive Selection on I-Maze Activity in *Drosophila melanogaster*. *Genetics* **71**:185-188.
- Gillespie, J. H. (1975): The Role of Migration in the Genetic Structure of Populations in Temporally and Spatially Varying Environments. I. Conditions for Polymorphism. *Am. Natur.* **109**:127-135.
- Ho, F. K. (1967): The Use of Vital Dyes for Marking *Tribolium* Eggs in Fresh and Aged Flour. *Tribolium Information Bulletin* **10**:103-105.
- Keim, B. H. (1976a): A Population Cage for Selection Experiments Involving *Tribolium*. *Tribolium Information Bulletin* **19**:130-131.
- Keim, B. H. (1976a): A Population Cage for Selection Experiments. Unpublished Ph.D. dissertation, Univ. of Virginia, Charlottesville.
- Lewontin, R. C. (1955): The Effects of Population Density and Composition on Viability in *Drosophila melanogaster*. *Evolution* **9**:27-41.
- Pimentel, D., Smith, G. J. C. and Soans, J. (1967): A Population Model of Sympatric Speciation. *Am. Natur.* **101**:493-504.
- Robertson, A. (1970): A Note on Disruptive Selection Experiments in *Drosophila*. *Am. Natur.* **104**:561-569.
- Scharloo, W. (1971): Reproductive Isolation by Disruptive Selection: Did It Occur? *Am. Natur.* **105**:83-86.
- Scharloo, W., den Boer, M. and Hoogmoed, M. S. (1967): Disruptive Selection on Sternopleural Chaetae Number. *Genet. Res.* **9**:115-118.
- Soans, A., Pimentel, D. and Soans, J. S. (1974): Evolution of Reproductive Isolation in Allopatric and Sympatric Populations. *Am. Natur.* **108**:117-124.
- Sokal, R. and Karten, I. (1964): Competition Among Genotypes in *Tribolium castaneum* at Varying Densities and Gene Frequencies (the Black Locus). *Genetics* **49**:195-211.
- Thoday, J. M. and Gibson, J. B. (1962): Isolation by Disruptive Selection. *Nature (London)* **193**:1164-1166.
- Thoday, J. M. and Gibson, J. B. (1970): The Probability of Isolation by Disruptive Selection. *Am. Natur.* **104**:219-230.
- Thoday, J. M. and Gibson, J. B. (1971): Reply to Scharloo. *Am. Natur.* **105**:86-88.

# Vegetational Role of Beech in the Southern Mixed Hardwood Forest and the Virginia Coastal Plain

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**Abstract**—Data on beech-rich upland hardwood forests of the central Coastal Plain of Virginia are analyzed in the light of the suggestion by Nesom and Treiber (1977) that beech-rich stands in North Carolina's Coastal Plain are steep-slope topo-edaphic communities. It is concluded that beech-white oak communities are not confined to steep slopes in the Virginia Coastal Plain, but are developing widely where disturbance has been stopped. A reanalysis of Quarterman and Keever's (1962) data on the Southern Hardwood Forest suggests that such Coastal Plain beech-white oak forests represent one end of a vegetational gradient which has laurel oak, sweet gum, and pignut hickory predominating at the opposite end.

## Introduction

Two recent studies on upland vegetation of the central Coastal Plain of Virginia (DeWitt & Ware, in press; Monette, 1975) conclude that beech (*Fagus grandifolia* Ehrh.) would be structurally important in the forests of the area if they were allowed to progress to a climax. These studies conclude further that the forests of this area show a closer structural relationship to the Southern Mixed Hardwood Forest of the southern Atlantic and Gulf Coastal Plains than to the oak-hickory forests of the Piedmont, with which the central Coastal Plain of Virginia has often been grouped by vegetation scientists (Braun, 1950; Küchler 1964).

Since the above studies were completed, Nesom & Treiber (1977) have published an interesting and provocative study of beech-rich hardwood forests in the North Carolina Coastal Plain, in which they conclude that those communities are not a part of the Southern Mixed Hardwood Forest type, but rather a unique topo-edaphic climax with its closest relations to the forests of the Piedmont. The implications for the Virginia Coastal Plain of the conclusions by Ne-

som & Treiber (1977) make necessary a careful reevaluation of the results and conclusions of Ware (1970), Monette (1975) and DeWitt & Ware (in press).

## Topo-edaphic Beech Communities

Nesom & Treiber (1977) described the beech-mixed hardwood communities of the North Carolina Coastal Plain as being on steep, primarily north-facing slopes and bluffs along streams. Top layers of soil were acidic (pH 6), and subsoils were circumneutral and often calcareous. White oak (*Quercus alba* L.), northern red oak (*Quercus rubra* L.), tuliptree (*Liriodendron tulipifera* L.) and sweet gum (*Liquidambar styraciflua* L.) were the codominants with beech. Scarlet oak (*Quercus coccinea* Muench.) and black gum (*Nyssa sylvatica* Marsh.), along with others, were important secondary species, and red maple (*Acer rubrum* L.) was very abundant in the understory. The phytogeographical significance of mountain laurel (*Kalmia latifolia* L.) in or adjacent to the beech communities was emphasized.

Beech is also regularly associated with steep slopes above streams in the central Coastal Plain of Virginia. This can be easily observed along Interstate 64 through the Peninsula of Virginia. Most small streams in the central Coastal Plain of Virginia tend to run north and south into the major (eastward-flowing) rivers, and thus these beech-rich slopes are as likely to be east- or west-facing as north-facing. Because the steep slopes drop so quickly, the width (upslope) of the stands is often too narrow for adequate vegetational sampling, and no quantitative data are presented here. However, tulip tree and white oak are usually important and northern red oak is sometimes present in these beech-rich stands. On some of the steepest slopes, especially those that are north-facing, mountain laurel may form a dense understory on the upper portion of the slope. In this study, the pH of these stands was not checked, but DeWitt & Ware (in press) found no pH values above 5.8 in the stands they tested, so these may well be acid also. At the base of some of these steep slopes the Yorktown formation, a Miocene shell deposit, is exposed. This formation underlies all of this portion of the upper Coastal Plain and no doubt insures a circumneutral subsoil on at least the lower portions of these slopes, just as Nesom & Treiber (1977) found in North Carolina.



These slopes are generally too steep for agriculture, and most show no evidence of ever having been cultivated. Most sites clearly have not been timbered in the last 100 years; and, judging from the size of the trees, some may never have been timbered. These areas may have been spared in the late 19th and early 20th centuries because of the difficulty of harvesting trees on such steep slopes, but in the last 50 years they have also been spared, perhaps because of the poor economic value of beech in a region largely oriented to pine and oak in its forestry. On surrounding, more gentle slopes and level areas, in sharp contrast to the beech-rich, steep slope areas, the forest has clearly come back on formerly cultivated land and usually shows evidence of two or more cuttings (for pine and/or oak) since cultivation ceased.

### Beech in Virginia Coastal Plain Uplands

If the beech-rich forests in the North Carolina Plain are steep-slope, topo-edaphic climaxes (Nesom & Treiber, 1977), two basic questions need to be answered about the Virginia Coastal Plain forests studied by DeWitt & Ware (in press) and Monette (1975): were a large number of their stands topo-edaphic steep-slope communities, and is beech an important species outside any such steep-slope communities?

In 8 of the 21 stands sampled by DeWitt & Ware, half or more of the sampled plots were on level ground, with none of the remaining plots having greater than 10° slope; in 2 others no plots had a slope greater than 5°; and two stands sampled by Monette (1975) were described by him as "level." Thus, 12 of the 27 stands used by DeWitt & Ware (in press) are very nearly level. In 5 other stands, half or more of the plots had slopes of 15° or greater, and 3 of these had at least 1 plot with a slope of 25° or greater. These five stands (only two of which have beech as a leading dominant) could be classified as occurring on "steep slopes." The 6 remaining stands sampled by DeWitt & Ware, and 4 other Monette-sampled stands described as "slightly" or "gently" sloping, make up 10 stands of intermediate slope. Considering the high degree of stream dissection in the central Virginia Coastal Plain, the ratio of 12/10/5 for level (nearly), intermediate sloping, and steeply sloping stands is probably a fairly representative sample. It is clearly not biased toward steep-slope communities.

Within the topographical range above, beech is not confined to the steeply sloping stands. Of the 11 stands in which beech is the leading dominant, only 2 are steeply sloping; 3 are level stands, and 6 are of intermediate slope. Of the 12 nearly level stands, beech occurs in 10, is the leading dominant in 3, and the second dominant in 2 others. White oak, another species Nesom & Treiber (1977) regarded as closely associated with the steep-slope community in North Carolina, is the leading dominant in eight of these nearly level stands, and the second dominant in three others.

As mentioned above, Nesom & Treiber (1977) regarded the high abundance of northern red oak, black gum, red maple, and scarlet oak in their steep-

slope stands as evidence of the similarity of these stands to similar topo-edaphic climax sites in the Piedmont. In contrast, DeWitt & Ware (in press) found all four of these species to be of rather low importance in their study sites and cited the low importance of the first three as examples of differences between upland forests of the Virginia Coastal Plain and the Piedmont.

Based on the above, one concludes that, in general, the beech-white oak communities upon which DeWitt & Ware (in press) and Monette (1975) based their conclusions about the Virginia Coastal Plain are not synonymous with the beech-rich topo-edaphic (steep slope) communities found by Nesom & Treiber (1977) in North Carolina and also occurring in similar sites in the Virginia Coastal Plain.

A clear distinction must be made between phyto-geographical relationships based on floristic analysis and vegetational relationships based on structural similarities. Nesom & Treiber (1977), for instance, classed both beech and white oak as mountain and/or Piedmont species, which in terms of their geographical and evolutionary origins, is indisputable. However, all available evidence for Virginia indicates that, in terms of vegetation, beech is more likely to be structurally important in the upland forests of the Coastal Plain (DeWitt and Ware, in press; Monette 1975) than it is in either the Piedmont (Gemborys 1974, Clark and Ware 1978, Diggs 1976 and unpublished) or the mountains (Braun 1950, Stephenson 1972, Johnson and Ware 1976, Watson 1977 and unpublished). Based on the same studies, it appears that white oak is as likely to be structurally important in the Coastal Plain as in the other two physiographic provinces.

### Beech in the Southern Mixed Hardwood Forest

Before discussing the relationship between the Virginia Coastal Plain hardwood forests and the Southern Mixed Hardwood Forest (SMHF), it seems worthwhile to take a close look at species associations within the SMHF itself. In their description of the SMHF in the southeastern Coastal Plain from Texas to South Carolina, Quarterman and Keever (1962) found few correlations between floristic composition and environmental factors in the stands they studied. However, they did not discuss the possibility of recognizing vegetational gradients based on correlations of the distributions of two or more species with one another, rather than with environmental factors. In this paper data from Table III of their 1962 paper are reexamined with that possibility in mind, and structural importance (rather than presence in the stands) is used as a measure in looking for species associations.

Quarterman and Keever (1962) presented their data on structural composition by assigning each species in a stratum of a stand to 1 of 10 DFD value classes, where DFD is the sum of relative dominance, relative frequency, and relative density, and each class spans 30 DFD units (out of the total of 300). Thus, a species assigned to DFD class 3 had a DFD value in that stratum in the range of 61 to 90. These

DFD class values are the data on which much of the following discussion is based.

Beech had the highest total DFD value when all 30 stands sampled by Quarterman & Keever (1962) were combined. There were 17 stands in which beech had a DFD class value of 2 or greater (DFD > 30) in the overstory (Table 1). Of the summed DFD class values for beech in the overstory of the sampled stands, 61 (of 65) occur in these 17 stands. The remaining 13 stands have relatively little beech, and in fact 5 of them have none in either overstory or understory. Of summed overstory and understory DFD class values for beech, 79 (of 90) occur in the first 17 stands.

The second most important hardwood tree species in the 30 sampled stands, laurel oak (*Quercus laurifolia* Michx.), shows a different DFD class distribution; only 19 of its summed DFD class values in overstory and understory are in the first 17 stands; 48 are in the remaining 13 stands. Thus, one could inter-

pret this to mean that laurel oak is at the opposite end of a vegetational gradient from beech. If the first 17 stands are arranged in order of decreasing importance of the combined (overstory and understory) DFD class values for beech, and the remaining 13 stands are arranged in order of increasing importance of laurel oak (beginning with the Berkeley 1, S.C. stand with no laurel oak), all 30 stands are then arranged in a vegetational gradient going from very pronounced beech dominance to very heavy laurel oak dominance (Table 1).

Since on a relative scale like DFD value an increase in the values for one species must automatically decrease the values of another, the gradient just mentioned could be challenged as an artifact. The very fact that stands can be so easily separated into two such groups, rather than there being numerous cases of codominance, is in itself a partial refutation of this possibility. However, a demonstration of a positive

TABLE 1

DFD class values in the overstory and understory of the SMHF vegetational gradient (based on Table III of Quarterman & Keever 1962). The SMHF abstract was based on the ten stands in their mid-mesic moisture class 4. Moisture classes 3 and 8 are level; 4 and 5 are rolling; and 6 and 7 are ravine slopes; moisture increases up the scale.

Stand No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Moisture Class	6	5	5	4	7	8	4	4	4	6	7	7	5	5	4	8	4	5	3	5	4	4	4	6	5	8	6	4	4	3	
Location	Stratum	Vernon La.	Hatchitoches La.	Polk Texas	Conchester S.C.	Perry Miss.	Targipahoa La.	Williamsburg S.C.	Lowndes 2 Ga.	Florence S.C.	E. Feliciana La.	Choctaw Ala.	Butler Ala.	Grant La.	Early Ga.	Wakulla Fla.	Eaker Ga.	Lowndes 1 Ga.	Berkeley 1 S.C.	Stone 1 Miss.	Jasper S.C.	Wilcox Ala.	Credy Ga.	Jackson Fla.	Wayne Ga.	Berkeley 2 S.C.	Columbia Fla.	Pulaski Ga.	Leon Fla.	Stone 2 Miss.	Pike Ala.
Species																															
<i>Fagus grandifolia</i>	o u	8 3	8 3	5 1	4 1	3 2	3 1	3 1	3 1	3 1	3 1	3 1	3 1	3 1	2 1	2 1	2 1	1 1	-	-	-	-	1 1	1 1	1 1	-	-	1 1	-	-	-
<i>Quercus laurifolia</i>	o u	1 -	-	2 1	1 1	-	-	1 2	3 1	-	-	-	-	-	1 1	2 1	-	1 1	-	1 1	-	2 1	1 1	1 1	1 1	2 1	3 1	3 3	3 3	6 2	10 2
<i>Quercus alba</i>	o u	-	1 1	2 1	2 1	-	-	1 2	-	2 2	3 1	5 1	2 1	-	2 1	2 1	1 1	2 1	-	1 1	-	-	-	2 1	1 1	1 1	-	1 1	-	1 2	-
<i>Liquidambar styraciflua</i>	o u	-	-	-	3 1	-	1 1	-	1 1	-	1 1	1 1	1 1	2 1	1 1	2 2	-	-	1 1	-	-	1 2	-	1 2	-	2 3	3 3	5 1	1 2	-	-
<i>Carya glabra</i>	o u	-	-	-	-	-	-	-	2 1	-	-	-	2 1	-	2 3	-	2 1	1 1	-	-	1 1	-	-	2 1	1 1	1 3	-	1 1	-	-	-
<i>Magnolia grandifolia</i>	o u	2 1	-	3 1	-	2 1	2 2	-	2 1	-	5 1	-	-	1 1	4 1	2 1	-	1 1	-	-	-	1 1	4 1	-	-	1 1	-	1 1	-	2 1	1 1
<i>Quercus nigra</i>	o u	-	-	-	1 2	1 1	1 1	1 1	1 1	2 1	1 1	-	-	-	1 1	1 1	1 1	1 1	2 1	2 3	1 1	-	1 1	-	1 1	1 1	-	3 1	-	1 1	
<i>Quercus falcata</i>	o u	-	-	-	1 1	-	-	2 2	-	1 1	-	1 1	-	3 1	-	2 1	-	1 1	-	6 1	-	2 1	-	2 1	1 1	-	1 1	-	1 1	-	-
<i>Carya tomentosa</i>	o u	-	-	-	2 1	-	-	1 1	1 1	-	2 1	2 1	1 1	-	1 1	1 1	1 1	1 1	-	-	-	2 2	-	3 2	-	-	-	-	-	-	-
<i>Nyssa sylvatica</i>	o u	-	1 1	-	-	1 1	-	1 1	-	-	1 1	1 1	1 1	-	1 1	-	1 1	1 1	-	-	-	-	-	1 1	1 1	-	-	-	-	1 1	-
<i>Ilex opaca</i>	o u	-	1 2	-	1 2	-	1 1	-	1 1	-	-	-	-	1 1	-	-	2 1	-	-	-	-	-	-	1 1	2 1	-	1 1	-	-	1 1	-
<i>Cornus florida</i>	o u	-	1 1	-	2 2	-	1 1	3 1	1 2	2 2	1 1	1 1	1 1	-	1 1	-	1 1	2 1	3 1	-	1 1	3 1	1 1	1 1	2 1	-	1 1	-	1 1	-	1 1
<i>Vaccinium arboreum</i>	o u	-	-	-	-	-	-	-	-	1 1	-	-	-	1 1	1 1	1 1	1 1	0 0	1 1	-	-	1 2	-	1 1	1 1	-	-	1 1	-	1 1	3 3
<i>Pinus taeda</i>	o u	-	2 1	3 3	2 1	1 1	-	4 1	1 1	-	-	-	2 1	1 1	1 1	-	1 1	4 1	-	6 1	10 2	4 1	-	1 1	3 1	-	-	6 1	2 1	-	-



rather than a negative correlation between relative values would be more easily accepted as signifying something about ecological realities, and the presence of such an association would strengthen the validity of an apparent dissociation, such as that between beech and laurel oak.

An examination of the distribution of the combined DFD class values for white oak (*Quercus alba* L.) reveals 38 in the 17 beech-rich stands and only 15 in the remaining 13 stands. This difference is significant at the 0.01 level (Chi square test). Thus, there is a positive association of white oak with beech, since the former occurs much more abundantly in stands where beech is also important, and this is despite the fact that the values being used are relative.

Neither sweetgum (*Liquidambar styraciflua* L.) nor pignut hickory (*Carya glabra* (Mill.) Sweet) show either negative or positive association with high importance of beech, but an inspection of Table 1 shows a concentration of high DFD class values for both sweetgum and hickory in the section of the vegetational gradient where laurel oak is also important (stands 24-28 for sweetgum, and 24-26 for pignut hickory). Further, these stands which are responsible for the occurrence of much of the sweetgum and pignut hickory among the first 17 stands also have higher DFD class values for laurel oak (4, 8, 15). All of this suggests a positive association between these two species and laurel oak.

If a new arrangement of stands is made (Table 2) based on decreasing DFD class values for laurel oak (ignoring the class value for beech), an even greater concentration of pignut hickory and sweetgum class values is achieved. In the 12 stands in which laurel oak has a class value of at least 1 in both overstory and understory, 25 of 35 summed pignut hickory

class values occur, as do 39 of 66 summed sweetgum class values. In both species the differences between these 12 and the remaining 18 stands is significant at the 0.01 level (Chi square test). Thus, it appears that the portion of the biological-environmental complex more favorable to laurel oak is also more favorable for pignut hickory and sweetgum, and that these three species constitute a group of strongly associated species distinct from the beech-white oak species association, despite the fact that any two of these five species (or all of them, as in stand 15) may occur abundantly in the same stand.

#### Vegetational Relationships of the Virginia Coastal Plain

In their study of forests of the central Coastal Plain of Virginia, Ware & DeWitt (in press) found white oak and beech to be the most important species, 1 or the other being the leading dominant in 22 of 27 stands. The 3 species associated at the other end of the SMHF vegetational gradient were relatively unimportant in the 27 stands they studied. Laurel oak, a very rare species so far north, did not occur in any of their sampled stands. Sweetgum was never a leading dominant, and exceeded an importance value of 10 percent (approximately equal to DFD class 2) in only 3 of 27 stands, with a maximum importance value of only 11.4 percent. Pignut hickory also was never a leading dominant, and exceeded an importance value of 10 percent in only one stand (where it reached 12.5%).

These data showing low importance of certain typical SMHF taxa do not necessarily indicate that the Virginia Coastal Plain forests are structurally distinct from the SMHF, but rather can be interpreted to

TABLE 2  
DFD class values in laurel oak-rich SMHF stands for three significantly associated species. See Table 1 legend.

Stand No.		30	29	28	27	8	26	25	15	17	24	4	23
Moisture Class		3	4	4	6	8	8	5	4	4	6	4	4
Species	Stratum												
Quercus laurifolia	o	10	6	3	3	3	3	2	2	1	1	1	1
	u	2	2	3	3	2	1	1	1	1	1	1	1
Liquidambar styraciflua	o	-	-	1	5	1	3	3	2	1	2	3	-
	u	-	-	2	1	1	3	3	2	3	1	1	1
Carya glabra	o	-	-	-	-	2	2	1	2	2	2	-	-
	u	1	-	-	1	1	3	1	3	1	1	1	1

mean that these forests represent only one half of the SMHF vegetational gradient, the other half having essentially disappeared. This would presumably be because the set of environmental conditions conducive to the development of forests of that composition are not frequently obtained in the Virginia Coastal Plain. Since the data on environmental variables (moisture class, topography, soil region and geographic area) reported by Quarterman and Keever (1962) do not correlate with the vegetational gradient, we do not know what environmental factors are responsible for the development (and disappearance in Virginia of one end) of the SMHF vegetational gradient.

While the much lower importance in Virginia of laurel oak, sweetgum, and pignut hickory are consistent with the hypothesis above, two other typically southern species of the SMHF, magnolia (*Magnolia grandiflora* L.) and water oak (*Quercus nigra* L.) are also absent or rare in the area studied. These two also did not occur in the sites studied by Nesom and Treiber (1977). The reason for the low importance of water oak in the upland forests of the Virginia Coastal Plain is not clear, for it shows no tendency to associate with one end of the SMHF gradient more than the other, and it does occur, sometimes abundantly, in floodplains in the central Coastal Plain (Glascoek and Ware, 1976).

While magnolia did not show a statistically significant association with beech in the SMHF, it reached DFD class 2 eight times in the 17 beech rich stands, versus only twice in the remaining 13 stands (Table 1). The absence of magnolia from the beech-white oak communities of the Virginia Coastal Plain reflects a real difference between this area and the SMHF. Considering that this area is outside the geographical range of magnolia (Fowells, 1965), however, its absence is not unexpected.

### Conclusions

Nesom & Treiber (1977) have argued convincingly that in the North Carolina Coastal Plain the beech-dominated steep slope and ravine communities, with their associated mesophytic shrubs and herbs, and relictual, having served as refugia in the warmer times since the last glacial period. I would concur based on observations in Virginia, and would add that these areas have probably also served as refugia during the last 370 agricultural years when most more gently sloping areas, more amenable to agriculture, have been cultivated or, post-cultivation, regularly timbered for pine. While the steep slope communities may be in part topographically, edaphically, and hy-

drologically controlled, the difference between them and the surrounding gentler slopes is also in part successional. Following the successional scheme proposed by Monette (1975), areas disturbed by cultivation and timbering would not be expected to have much beech until long after all disturbance ended. Based on the finding of DeWitt & Ware (in press) and Monette (1975 and unpublished) of much beech on level and gently sloping areas formerly cultivated, I conclude that with the retreat of heavy agricultural pressure in the central Coastal Plain of Virginia, the forest type found in these refugia is spreading onto the surrounding gentle slopes and level uplands. Ultimately, if succession is not stopped by lumbering or development, there should develop a beech- and white oak-dominated forest strikingly different in vegetational structure from the beech-poor upland forest types of the neighboring Piedmont to the west, and showing its greatest structural similarity to the beech-rich half of the SMHF vegetational gradient of the southern Coastal Plain.

### Literature Cited

- Braun, E. L. (1950): Deciduous Forests of Eastern North America, 596 p. The Blakiston Co., Philadelphia, Pa.
- Clark, D., and Ware, S. (1978): Upland Hardwood Forests of Pittsylvania Co., Va. Va. J. Sci. **29**: (in press).
- DeWitt, R. and Ware, S. (in press): Upland Hardwood Forests of the Central Coastal Plain of Virginia. *Castanea*.
- Diggs, G. (1976): The Vascular Flora of the Kent Branch Drainage System Fluvanna Co., Va. Va. J. Sci. **27**:55.
- Fowells, H. A. (1965): Silvies of Forest Trees of the United States, 762 pp. Agricultural Handbook No. 271: USDA, Washington, D. C.
- Gemborys, S. (1974): The Structure of Hardwood Forest Ecosystems of Prince Edward County, Virginia. *Ecol.* **55**:614-621.
- Glascoek, S., and Ware, S. (1976): Forests of Small Stream Bottoms in the Peninsula of Virginia. Va. J. Sci. **27**:56.
- Johnson, G. and Ware, S. (1976): Forest Vegetation of the Peaks of Otter Area of the Virginia Blue Ridge. Va. J. Sci. **27**:57.
- Kühler, A. W. (1964): Potential Natural Vegetation of the Conterminous United States, 116 pp. Special Publication No. 36, The American Geographical Society, New York.
- Monette, R. (1975): Early Forest Succession in the Southeastern Virginia Coastal Plain. Va. J. Sci. **26**:65.
- Nesom, G. L. and Treiber, M. (1977): Beech-Mixed Hardwoods Communities: a Topo-Edaphic Climax of the North Carolina Coastal Plain. *Castanea* **42**:119-140.
- Quarterman, E. and Keever, C. (1962): Southern Mixed Hardwood Forest: Climax in the Southeastern Coastal Plain: U.S.A. *Ecol. Monog.* **32**:167-185.
- Stephenson, S. G. (1972): Ecological Composition of Some Former Oak-Chestnut Communities in Western Virginia. *Castanea* **39**:278-286.
- Ware, S. (1970): Southern Mixed Hardwood Forest in the Virginia Coastal Plain. *Ecol.* **51**:921-924.
- Watson, F. (1977): The Vascular Flora of Three Ridges Mountain, Nelson Co., Va. Va. J. Sci. **28**:77.



# Minimum Age of the Pilot Knob Iron Ore Body, St. Francois Mountains, Southeastern Missouri

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**Abstract**—The apparent Rb-Sr age of K-feldspar samples from a vein cutting magnetite-hematite ore and from the silicate matrix of "breccia ore" at the Pilot Knob Mine, St. Francois Mountains, Missouri is  $1180 \pm 35$  m.y. old. Regional geochronological studies indicate that most of the volcanic rocks which are the hosts of the ore and the associated shallow intrusive rocks are 1500 m.y. old. The age of the feldspar samples is therefore considered a minimum age and indicates that the age of the ore body is in the interval 1180 to 1500 m.y. age.

Regional lowering of Rb-Sr ages and other evidence suggest that a widespread hydrothermal event occurred in this area about 1300 m.y. ago or somewhat more recently. This event may be related to the mineralization of rocks and the formation of several ore bodies in this area.

## Introduction

The Pilot Knob Ore Body occurs within Precambrian volcanic rocks of the St. Francois Mountains of southeastern Missouri (Figure 1). In this region, which is located about 160 km (100 mi) south of St. Louis, is exposed a sequence of rhyolite flows and rhyolitic ash flow tuff units and associated shallow granitic intrusives, all of which were formed about 1500 m.y. ago (Bickford and Mose, 1975). These rocks are a major exposed portion of an extensive terrane of similar rocks which is known in the subsurface from northern Ohio to the Texas Panhandle (Lidiak et al., 1966; Muehlberger et al., 1966; Bass, 1960; Snyder, 1968a). Bickford and Van Schmus (1973) have called attention to the arcuate pattern formed by this terrane and suggested that it may represent an ancient volcano-plutonic arc structure which was formed on the margin of pre-existing continental crust.

The geology of this region has been discussed by Tolman and Robertson (1969), and more detailed

descriptions of volcanic stratigraphy and petrology have been published by J. E. Anderson et al. (1969), by R. E. Anderson (1970), and by Berry and Bickford (1972). Amos and Desborough (1970) have discussed the petrology of the numerous small basic intrusive bodies of the region.

The Precambrian rocks of the St. Francois Mountains are of major economic interest because of the occurrence of several mineable bodies of magnetite and hematite; these include the Pilot Knob Ore Body, the Pea Ridge Ore Body, and the deposits at Iron Mountain. These bodies, which appear to have been emplaced during a widespread hydrothermal or magmatic-hydrothermal event, have been discussed by G. Kisvarsanyi (1973, 1966); Snyder (1969, 1968b, 1966); Smith (1968); Murphy and Ohle (1968); Emery (1968); Johnson (1961); and Hayes (1959).

Early geochronological studies of these rocks include those of Allen et al. (1959), Tilton et al. (1962), and Muehlberger et al. (1966). These studies were done on single minerals or single whole rock samples by U-Pb, Rb-Sr, and K-Ar methods, and indicated age values ranging from 1190 to 1525 m.y. Systematic Rb-Sr measurements on collections of whole rock samples were first made by Bickford and Odom (1968) and yielded ages of 1300 to 1400 m.y., but the later Rb-Sr studies of Mose and Bickford (1972) showed that rocks in this area have not remained completely closed systems with respect to Rb and Sr, and ages determined by this method are probably too low.

In another paper (Bickford and Mose, 1975), the results of U-Pb measurements are reported on zircons separated from most of the rock units in the St. Francois Mountains, and additional Rb-Sr measurements made on collections of rocks from the intrusive masses. The U-Pb data indicate that all of the rock units studied, with the exception of the Munger Granite Porphyry, were formed about  $1500 \pm 30$  m.y. ago; the Munger Granite Porphyry is apparently about 1400 m.y. old.

It is the purpose of this paper to present Rb-Sr measurements on feldspar samples which were taken from veins cross-cutting ore in the Pilot Knob Ore Body, and feldspar samples from the silicate "matrix" of so-called "breccia ore" in that ore body. These measurements have allowed calculation of the

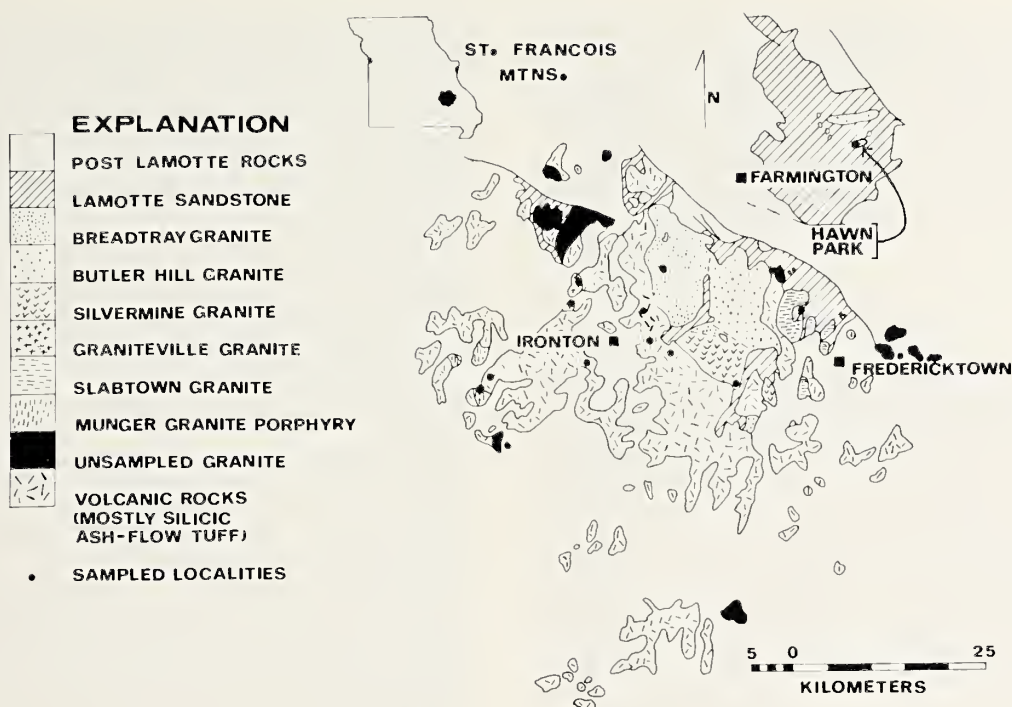


FIG. 1—Sketch geological map of the St. Francois Mountains region, southeastern Missouri. The Pilot Knob Mine is about two km north of Ironton. Dots indicate localities sampled for regional geochronological study of Bickford and Mose (1975).

minimum age of the ore body and hence of the period of mineralization.

#### Problem of the Origin and Age of the Mineralization

Ore bodies in the Precambrian of the St. Francois Mountains are of both concordant and discordant types (Snyder, 1968b). Concordant types generally show replacement textures and are believed to represent host volcanic rocks which were replaced by iron oxides. The upper exposed parts of the Pilot Knob Ore Body are of this type. Discordant bodies display breccia blocks of host rocks enclosed by iron oxides. Bodies of both types have been ascribed to replacement or deposition by hydrothermal fluids of magmatic origin. However, the Pea Ridge Ore Body, which is a massive tabular body of magnetite and hematite emplaced in volcanic rocks, is believed by Emery (1968) to be the result of forceful emplacement by an iron-rich differentiate of silicic or intermediate magma. Desborough (1963) has suggested that the iron was derived from the alteration of titaniferous magnetite. Snyder (1968b) has pointed out that chemical analyses of the granitic intrusive rocks consistently show less iron than analyses of the volcanic rocks, and has suggested that the iron-bearing solutions were derived during differentiation of magmas which produced both the extrusive rocks and the slightly later intrusives.

There is a general opinion that the ore deposits are genetically related to the igneous activity which formed the host rocks, but the exact process is still a matter of controversy. It is clear, however, that the age of the ore bodies is critical to any interpretation

of their origin. Muehlberger et al. (1966) have reported a Rb-Sr age of 1390 m.y. from an aplite dike which cuts ore at Pea Ridge. This age determination, which is recalculated from the original data using  $1.39 \times 10^{-11}$  yr for the decay constant of Rb<sup>87</sup>, indicates that the Pea Ridge Ore Body is older than this. Muehlberger et al. also reported a Rb-Sr age of 1370 m.y. for the host rock rhyolite at Pea Ridge; but, as discussed by Bickford and Mose (1975), this age is probably younger than the true age of the rock by as much as 10 percent.

#### The Pilot Knob Ore Body and the Nature of Our Samples

The Pilot Knob Ore Body has been described by Johnson (1961) and Snyder (1968b). The earliest mining was from mineralized tuff and breccia exposed on Pilot Knob, a prominent hill located a few miles north of Ironton, Missouri, at the site of the village of Pilot Knob. The ore mineral is specular hematite, which replaces the tuff and the breccia matrix (Snyder, 1968b). Current mining by the Pilot Knob Pellet Company is from an underground ore body which consists principally of massive iron oxides with lesser amounts of "breccia ore."

The samples used in this study consist of feldspar from two localities within the mine. Sample A, from Stope 158B on the 1360 level, occurred in a pod in breccia ore; Sample B is from a silicate vein cutting massive ore in Stope 418C on the 1230 level. The mode of occurrence of both samples indicates that they were formed subsequent to the formation of the ore.



TABLE 1  
*Analytical data*

Sample	Rb <sup>87</sup> (ppm)	Sr <sup>86</sup> (ppm)	(Rb <sup>87</sup> /Sr <sup>86</sup> )*	(Sr <sup>87</sup> /Sr <sup>86</sup> )*
A	290.8	0.752	108.2	2.499
	284.4	0.769	103.5	2.427
B	211.6	14.80	4.00	0.7802
	212.9	15.10	3.94	0.7774

\* atomic ratio

### Geochronology

The age determinations reported here were done in the laboratories of the Department of Geology, University of Kansas by standard techniques. Details of sample preparation, laboratory procedure, analytical precision, natural constants, and instrumentation, are given in Bickford et al. (1969) and in Bickford and Mose (1975).

Two portions of each feldspar sample were analyzed for Rb, Sr, and Sr isotopic composition. These data are given in Table 1. The differences in analytical results between the two portions of Samples A and B represent inhomogenities in the feldspar samples, since they are outside of analytical uncertainties determined in our laboratory (Mose and Bickford, 1972).

To determine the age of the two samples, an isochron was drawn through plotted points representing the analytical data (Figure 2). This treatment depends upon the assumption that both of the samples are coeval, cogenetic and have remained closed chemical systems to Rb and Sr isotopes since they formed. The age of this array of points, as determined by the least-squares-regression technique of York (1966), is  $1180 \pm 35$  m.y. (95 percent confidence level) with an initial  $\text{Sr}^{87}/\text{Sr}^{86}$  ratio of  $0.713 \pm 0.002$  ( $^{87}\text{Rb}$  decay constant =  $1.39 \times 10^{-11}/\text{yr}$ ).

### Discussion

The apparent age determined, 1180 m.y., represents only the minimum age of the Pilot Knob Ore

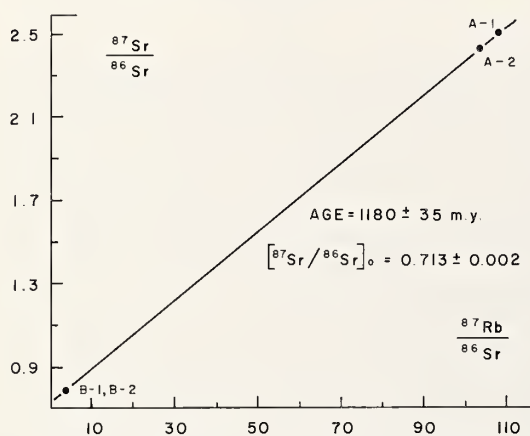


FIG. 2—Isochron diagram for K-feldspar samples from Pilot Knob Mine. The dashed isochron is for samples B-1 and B-2 assuming that the initial  $\text{Sr}^{87}/\text{Sr}^{86}$  ratio was 0.705; the solid isochron is drawn through all 4 analytical points.

Body, since it is for K-feldspar which is younger than ore. Although the age of the host rocks at Pilot Knob has not been determined, regional geochronological studies in the St. Francois Mountains (Bickford and Mose, 1975) strongly suggest that all of the volcanic rocks and most of the intrusive masses are 1500 m.y. old. The formation of the ore thus occurred at some time during the interval from 1180 to 1500 m.y. ago.

The volcanic and intrusive rocks studied by whole-rock Rb-Sr methods in the St. Francois Mountains yield isochrons indicating ages ranging from 1280 to 1410 m.y., but most are about 1300 m.y. old. There is strong evidence that these ages represent an event in the postcrystallization history of the rocks during which Sr was partially to largely lost from the rock systems. It has been argued (Bickford and Mose, 1975) that the alteration of these rocks by hydrothermal waters is the most likely event which could account for the Rb-Sr ages. If this is so, the period of alteration must have occurred at least somewhat more recently than 1300 m.y. ago.

Wenner and Taylor (1972) have reported that studies of oxygen and hydrogen isotopes in these rocks indicate that extensive exchanges occurred between the rocks and water, which was either magmatic in origin or meteoric water whose isotopic composition was different from that of present day seawater. It is not known whether this event is the same one which resulted in the mineralization of these rocks, nor can it be definitely established that this event is related to the lowering of Rb-Sr ages.

In summary, the data presented here fix the minimum age of mineralization at Pilot Knob at  $1180 \pm 35$  m.y. Other considerations discussed above strongly suggest, but do not prove, that mineralization was associated with widespread hydrothermal alteration of the host rocks about 1300 m.y. ago.

### Acknowledgments

Mr. David Nicholas, Geologist of the Pilot Knob Pellet Company, collected the samples in the mine at Pilot Knob, Missouri. Financial support for certain relevant aspects of the field work was provided by the Missouri State Geological Survey and a Grant-in-Aid of Research from the Society of the Sigma Xi. Financial support for the analytical work was provided by the National Science Foundation under grant GA-11128. Data reduction was done on the Honeywell 635 computer at the University of Kansas Computation Center.

### Literature Cited

- Allen, V. T.; Hurley, P. M.; Fairbairn, H. W. and Pinson, W. H. (1959): Age of Precambrian Igneous Rocks of Missouri. *Bull. Geol. Soc. Am.* **70**:1560-61.
- Amos, D. H. and Desborough, G. A. (1970): Mafic Intrusive Rocks of Precambrian Age in Southeast Missouri (Contribution to Precambrian Geology No. 3). *Missouri Geol. Sur. and Water Res., Rept. Inv.* **47**, 23 pp.
- Anderson, J. E.; Bickford, M. E.; Odom, A. L. and Berry, A. W., Jr. (1969): Some Age Relations and Structural Features of the Precambrian Volcanic Terrane, St. Francois Mountains, Southeastern Missouri. *Bull. Geol. Soc. Am.* **80**:1815-1818.
- Anderson, R. E. (1970): Ash-Flow Tuffs of Precambrian Age in Southeast Missouri (Contribution to Precambrian Geology

- No. 2). Missouri Geol. Sur. and Water Res., Rept. Inv. 46, 50 pp.
- Bass, M. N. (1960): Grenville Boundary in Ohio. *J. Geol.* **68**:673-677.
- Berry, A. W., Jr. and Bickford, M. E. (1972): Precambrian Volcanics Associated with the Taum Sauk Caldera, St. Francois Mountains, Missouri, U.S.A. *Bull. Volc.* **36-2**:308-318.
- Bickford, M. E.; Baker, F.; Wetherill, G. W. and Lee-Hu, Chin-Nan (1969): Precambrian Rb-Sr Chronology in the Needle Mountains, Southwestern Colorado. *J. Geophys. Res.* **74**:1660-1676.
- Bickford, M. E. and Mose, D. G. (1975): Geochronology of Precambrian Rocks in the St. Francois Mountains, Southeastern Missouri. *Geol. Soc. Am., Special Paper* 165, 48 pp.
- Bickford, M. E. and Odom, A. L. (1968): Rb-Sr Geochronology of Igneous Events in the Precambrian of the St. Francois Mountains, Southeastern Missouri (abs.). *Geol. Soc. Am. Annual Meeting, Program with Abstracts*, p. 27.
- Bickford, M. E.; and Van Schmus, W. R. (1973), Possible Middle and Late Precambrian Igneous Arcs in the Mid-continent Region of North America (abs.). *Geol. Soc. Am., abstracts with programs*, 5:300.
- Desborough, George A. (1963): Mobilization of Iron by Alteration of Magnetite-Ulvospinel in Basic Rocks in Missouri. *Econ. Geol.* **58**:332-346.
- Emery, J. A. (1968): Geology of the Pea Ridge Iron Ore Body in Ore Deposits of the United States, 1933-1967, vol. 1 (John D. Ridge, ed.), *Am. Inst. Min., Met., and Pet. Eng.*, pp. 359-369.
- Hayes, W. C. (1959): Geology and Exploration of Missouri Iron Deposits. *Missouri Geol. Sur. and Water Res., Misc. Pub.*, 16 pp.
- Johnson, C. H. (1961): A Brief Description of Pilot Knob. In *Guidebook to the Geology of the St. Francois Mountain Area*: Missouri Geol. Sur. and Water Res., Rept. Inv. 26, pp. 127-128.
- Kisvarsanyi, G. (1966): Geochemical and Petrological Study of the Precambrian Iron Metallogenic Province of Southeast Missouri. Unpub. Doctoral dissert., Univ. Missouri-Rolla.
- Kisvarsanyi, G. (1973): Geological Sequence of Igneous Activity in the Precambrian St. Francois Terrane, Missouri (abs.). *Geol. Soc. Am., abstracts with programs*, vol. 5, p. 327.
- Lidiak, E. G.; Marvin, R. G.; Thomas, H. M. and Bass, M. N. (1966): Geochronology of the Mid-Continent Region, United States, Part 4, Eastern Area. *Hour. Geophys. Res.* **71**:5427-5438.
- Mose, D. G. and Bickford, M. E. (1972): Chronology of Precambrian Volcanic Units in the Central St. Francois Mountains, Missouri, 24th Int. Geol. Cong., Sec. 1, pp. 230-237.
- Muehlberger, W. R.; Hedge, C. E.; Denison, R. E. and Marvin, R. G. (1966): Geochronology of the Midcontinent Region, United States, Part 3, Southern Area. *J. Geophys. Res.* **71**:5409-5426.
- Murphy, J. E. and Ohle, E. L. (1968): The Iron Mountain Mine, Iron Mountain, Missouri. In *Ore Deposits of the United States, 1933-1967*, vol. 1 (John D. Ridge, ed.), *Am. Inst. Min., Met., and Pet. Eng.*, pp. 287-302.
- Smith, F. (1968): Mineralization of the Boss-Bisby Anomaly, Iron and Dent Counties, Missouri. Unpub. Masters Thesis, Univ. of Missouri-Rolla.
- Snyder, F. G. (1966): Precambrian Iron Deposits in Missouri (abs). *Econ. Geol.* **61**:799.
- Snyder, F. G. (1968a): Tectonic History of Midcontinental United States. *Univ. Missouri-Rolla J.*, no. 1, ser. 1, pp. 65-77.
- Snyder, F. G. (1968b): Geology and Mineral Deposits, Mid-continent United States. In *Ore Deposits of the United States, 1933-1967*, vol. 1 (John D. Ridge, ed.), *Am. Inst. Min., Met., and Pet. Eng.*, pp. 257-286.
- Snyder, F. G. (1969): Precambrian Iron Deposits in Missouri. In *Magmatic Ore Deposits—a Symposium* (H.D.B. Wilson, ed.), *Econ. Geol. Mon.* **4**:231-238.
- Tilton, G. R.; Wetherill, G. W. and Davis, G. L. (1962): Mineral Ages from the Wichita and Arbuckle Mountains, Oklahoma, and from the St. Francois Mountains, Missouri. *J. Geophys. Res.* **67**:4011-4020.
- Tolman, C. and Robertson, F. (1969): Exposed Precambrian Rocks in Southeast Missouri. *Missouri Geol. Sur. and Water Res., Rept. Inv.* 44, 68 pp.
- Wenner, David B. and Taylor, Hugh P. (1972):  $O^{18}/O^{16}$  and D/H Studies of a Precambrian Granite-Rhyolite Terrane in S. E. Missouri (abs.). *Trans. Am. Geophys. Union*, **53**:534.
- York, Derek (1966): Least-Squares Fitting of a Straight Line: *Canadian J. Physics* **44**:1079-1086.

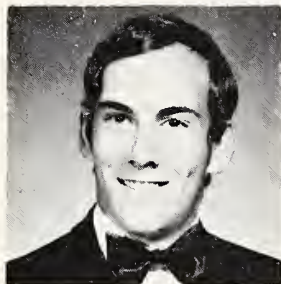


# Birds as Vectors of Vegetative Plant Parts and Plant Pathogens: A Review

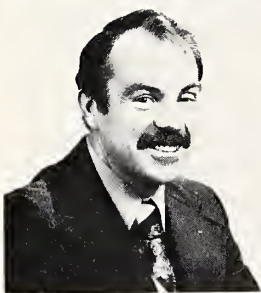
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## Introduction

In 1965, a new disease of peanuts, *Cylindrocladium* Black Rot (CBR), was discovered in Georgia (Bell and Sobers, 1966). The disease spread rapidly northwards, and the disjunct pattern of incidence prompted suspicion that birds might be vectors. A study (Hiller, 1978) was conducted to examine the potential role of birds, part of which was a review of literature on the role of birds in spreading plant parts and plant disease organisms. Birds are well recognized for their important ecological role as dispersers of plant seeds. Excellent reviews (e.g. Janzen, 1971) exist on this topic. The intent here is to deal primarily with those aspects of birds' function as vectors of plant components which have the potential to contribute to the spread of plant disease.

## Birds as Vectors of Plant Parts

*Dispersal of Seeds by Birds*—Birds are well-known dispersers of many different plant seeds. Janzen (1971) gives a broad review of seed predation by both birds and mammals and cites several examples of dispersal of seeds by birds. One aspect of seed dispersal is the benefit to some species of seed passage through the gastro-intestinal tract of vertebrates.

This enhances germination of seeds in some cases (Krefting and Roe, 1949; Olson and Blum 1968). Short distance dispersal was shown by Fordham (1967).

Examples of long-distance dispersal of seeds by birds are numerous. Cleland (1952) reported that several plant species in Australia had been spread via seeds in birds. Viable seeds were found in the gizzards of snow buntings captured on a new volcanic island where there were no plants to produce seeds (Sigurdsson and Fridriksson, 1969). Proctor (1968) showed that several factors were involved with the dispersal of seeds, such as size of the seed, digestive action, and diet. He noted that seeds were retained up to 200 or 300 hours in the gastro-intestinal tract. Proctor also found that some seeds were regurgitated. It has been suggested that this regurgitation may be a possible method of dispersal for propagules that cannot survive passage through the entire tract (Malone, 1966). Falla (1960) mentioned several pelagic bird species as dispersal agents. Besides internal transport of seeds, Cruden (1966) reviewed the possibilities of seeds being carried in mud on the feet of birds. He cited an article by Darwin in 1859 and several others which alluded to this possibility.

A few instances of detrimental seed dispersal are also known. Seeds of the mistletoe were shown to be spread by birds in the southwest United States (Bray, 1910). Zilka and Tinnin (1976) suggested that 10 out of the 80 bird species they studied could be important vectors of dwarf mistletoe. The sticky seeds were found on feathers, but not in droppings.

*Dispersal of Other Plant Parts by Birds*—Sometimes other organisms and plant parts along with seeds are transported or moved about by birds. Plankton (and interestingly the eggs of brine shrimp) were found viable in the fecal contents of Mallards (*Anas platyrhynchos*; Malone, 1965). A species of spartina was found over 85 km from its nearest point of establishment in the fjords of Denmark, strongly suggesting bird dispersal (Adersen, 1974). Schlichting (1960) discussed the role of waterfowl in carrying algae between bodies of water, as did Proctor (1959). Proctor found the algae with simpler cells were viable in the gastro-intestinal tract, while the complex types were not. Twenty-eight genera of algae were present in one species. De Vlaming and Proctor (1968) found several species of aquatic organisms viable after passage through killdeer (*Chadrius vociferus*) and mallards.



A case of short-distance dispersal of plant parts involved moss and several bird species associated with beech forests in England (Davison, 1976). Apparently various sized pieces of moss were dislodged and spread about during foraging by bird species. Davison also suggested that either pieces of moss or spores could be carried on the feet or in the feathers of birds, efficiently spreading the moss greater distances.

### Pathogenic Fungi in Seeds

With the high incidence of seed dispersal by birds, the possibility of spreading a pathogenic fungus via seeds seems great, especially when a great number of fungi are seed-borne. The literature contains many instances of fungi inhabiting seeds of many plants, particularly domesticated plant species. This would be expected since crops and their welfare are of great interest to man and are more thoroughly researched. A few cases where seeds of various plants have been found to contain pathogenic fungi are presented.

Species of *Botrytus* and *Sclerotinia* were isolated from chickpea seeds by Cothier (1977). Both are important pathogenic genera. Nik and Parbery (1977) isolated 42 different species of fungi from the seeds of 25 legumes. Ameson and Stiers (1977) isolated *Cephalosporium gramineum* from seeds, and *Drechslera* spp. were identified as seed-borne pathogenic fungi isolated from cereal seeds in New Zealand by Sheridan (1977).

In studying the possibility of *Cylindrocladium crotalariae*'s being seed-borne, Garren et al. (1972) succeeded in isolating the fungus from freshly dug peanuts, *Arachis hypogaea*, but not from peanuts subjected to normal on-farm processing. This was true even when peanuts were hand picked from 100 percent diseased plants and then processed for market. This process involves drying in the field while exposed to depredation by birds. Hanlin (1973) reported a total of 200 species (110 genera) of fungi recovered from all parts of the peanut plant, including the seed.

The dispersal of pathogenic fungi on seeds by birds would involve survival of the fungi while passing through the gastro-intestinal tract of the birds in cases where the seeds are ingested. In those instances where seeds are ingested and later regurgitated, fungi would not be subjected to the entire process of passage through the gastro-intestinal tract and their survival prospects might thus be enhanced. No instance of survival of fungi following passage through the gastro-intestinal tract was found. Hiller (1978) examined the fate of microsclerotia of *Cylindrocladium crotalariae* ingested by the Canada geese (*Branta canadensis*), bobwhite quail (*Colinus virginianus*), and Japanese quail (*Coturnix coturnix japonica*). Survival as evidenced by culture of fecal material was not found in any species except in 2 of 15 geese which had 5000 microsclerotia fed to each enclosed in a porous, synthetic cloth material. In those geese yielding viable microsclerotia only 2 and 3, respectively, survived.

Examination of soil from a blackbird roost in the peanut-growing area in Virginia proved negative for CBR (Hiller, 1978). Presumably, if infected peanuts

were ingested the fungus did not survive passage through the gastro-intestinal tracts of the blackbird species.

Pathogenic fungi on seeds borne outside the body (e.g. on feet or in the feathers) could conceivably survive more readily. However, they would have to withstand such factors as desiccation in order to survive.

### Dispersal of Fungi and Other Organisms

Only a few kinds of plant pathogens have any independent movement, which in any case is insignificant for long-distance dispersal. Thus, all pathogens depend on agents other than themselves for dissemination. These agents are wind, water, insects, man, and other animals (Agrios, 1969). To discuss these aspects in detail is beyond the scope of this review.

*Dispersal by Animals*—Several instances of animals, primarily birds, carrying fungi have been documented. These involve the presence of fungi only, and do not necessarily imply the spread of a disease caused by those fungi. However, the possibility of their being disease vectors is obvious.

Besides giving a general review on dispersal of fungi, Ingold (1953) mentions the dispersal of freshwater aquatic fungi by waterfowl. Extensive work on birds and their association with fungi either in feathers, nests, or soil has been done by Pugh (1964, 1965a, 1965b, 1966a, 1966b, 1972), and Pugh and Evans (1970). European birds were regularly shown to carry fungi, some of which were pathogenic. The nests of birds also frequently contained certain types of fungi. Cooney and Emerson (1965) also found fungi (possibly pathogenic) in birds' nests, as did Apinis and Pugh (1967), who isolated 27 species from plant debris found in the nest itself. Another researcher has shown high levels of occurrence of fungi on feathers and bird nests also (Hubalek 1972, 1974, 1976). One instance of other animal involvement with fungi concerned the isolation of fungi from the nests of 5 Muridae rodent species in Europe (Trykoz, 1975). Pollen along with fungal spores were shown to be carried by birds (Ash et al., 1961). Several genera of fungi, including pathogenic forms, were isolated from the feet of birds by Evans and Prusso (1969), who believed their results warranted further studies. Fungi were also isolated from the throats and feathers of wild pink-footed geese (*Anser brachyrhynchos*) sampled in Scotland and Iceland (Sladen and Austwick, 1955). Seventeen different genera of fungi associated with these geese were determined to have been picked up in fields by the geese.

An in-depth study into the ability of birds to carry fungi was carried out by Warner and French (1970). They applied spores of 2 fungi to the plumage of 149 birds of 31 species and recovered viable spores 3 to 45 days later. They also isolated fungi of 39 genera, some of which were pathogenic, from the feathers of 248 birds collected in parts of Mexico, Texas and Minnesota. Their work also showed that common grackles (*Quiscalus quiscula*) spread two diseases of oats from field plants to healthy plants under greenhouse conditions. Monga (1972) isolated several gen-



era of pathogenic fungi from 60 of 233 wild birds he collected.

Birds, especially woodpeckers, were shown to be involved in the economically important spread of chestnut-blight, cause by *Endothia parasitica* (Heald and Studhalter, 1914). In similar work, Tiffany et al. (1955) attempted to isolate the causal fungus of oak wilt from birds. Although they failed to isolate that particular fungus, they found 41 different genera of fungi associated with birds. Magpies (*Pica pica*) were implicated in the spread of a fungus causing dieback of citrus trees (Kouyeas and Anastassiadis, 1962). The birds built nests from twigs killed by the fungus and thus caused its spread to healthy trees.

There are several cases where birds were suspected of spreading a disease by carrying fungi. Lachmund (1929) suggested that birds were involved in the spread of the sweetfern rust. Migratory birds were considered to be the agent of transfer of blister-blight of tea from Ceylon to Sumatra (Reitsma and Van Emden, 1949). Birds may also be the dispersal agent of blister-blight of tea in New Guinea (Shaw, 1965). Nielson (1929) suggested that birds aided in the distribution of the potato wart disease fungus.

*Dispersal of Organisms Other than Fungi*—Birds have been shown to transport or be involved in the spread of other organisms besides plants and fungi, some being of a pathogenic nature. The spread of plant viruses by birds has been shown in several instances (Broadbent and Martini, 1959; Broadbent 1964, 1965).

Yeasts have been carried by birds (Kocan and Hascenclever, 1974), and Tiunina (1931) suggested that birds may contribute to the spread of yeasts in French vineyards.

Plant pathogenic bacteria carried by birds were involved with a coconut bud-rot (Johnston, 1912). Babbar et al. (1975) isolated avian mycoplasma from plants, suggesting bird involvement.

Of a nonpathogenic nature but with interest to this review are crustacean eggs, which were recovered in a viable condition from the cloaca of ducks by Proctor (1964). This and all instances mentioned earlier involving the gastro-intestinal tract of birds raise questions about the environment encountered by organisms when ingested. The following section deals with this aspect.

### The Avian Digestive System

It seems unlikely that plant pathogenic fungi would survive passage through the avian digestive tract. Farner and King (1972) and Sturkie (1976) review the characteristics of the avian digestive system. Extremely acid conditions ( $\text{pH} \leq 1$ ) prevail in part of the tract while later secretions are alkaline ( $\text{pH} \geq 8$ ). Physical maceration of ingested materials takes place in the gizzard.

From the standpoint of the potential for long-distance dispersal of plant pathogens surviving passage through the gastro-intestinal tract, the rapid transport through the avian digestive system would appear to be a limiting factor. Passage of ingested foods may be as short as 2.5 hours, and usually does not exceed 24 hours.

### Fungal Spore Passage Through Various Organisms

Recorded instances of fungi surviving passage through the gastro-intestinal tract of organisms are few. Heald (1943) believed that few if any propagules of corn smut could survive passage through the gastro-intestinal tract of horses or cattle. Peplinski (1974) failed to isolate viable propagules of *Ceratocystis fagacearum* in the frass of two species of beetles associated with the death of red oaks. However, spores of the pathogenic fungus, *Colletotrichum lagenarium*, passed through the gut of a snail and were viable for several days, causing anthracnose of melon (Hasan, 1976). Similarly, Gilliam (1972) isolated fungi from the intestinal contents of worker honeybees.

### Conclusions

While birds are efficient as dispersers of intact seeds, their role in spreading other plant parts remains limited. Most of the evidence for birds transporting vegetative plant parts remains confined to waterfowl and aquatic species of plants. Migrating waterfowl could conceivably transport such plant materials for long distances on their feet, provided the plants survived desiccation.

The potential role of birds as vectors of plant disease remains a matter for speculation. No instances were found in the literature where plant disease organisms survived passage through the gastro-intestinal tract. Should plant diseases survive passage through the gastro-intestinal tract, the potential for long-distance transfer is limited because of the relatively short time it takes for foods to be digested by birds. However, the short time for food passage would not limit local spread (i.e. dispersal over short distances).

Transportation of plant pathogens on external body parts could be more feasible provided the pathogens are resistant to desiccation. Such transport would most likely be of soil-borne organisms. Cereal rusts have been shown to be transported in feathers of birds. Such transportation by migrating species would be limited by the availability of a source of contamination (presumably aerial parts of plants) at some point on the migration path of the birds. However, birds may be important vectors for local spread of plant diseases, but much research on this subject is needed to confirm their roles relative to other methods of spread.

### Literature Cited

- Aderson, H. (1974): *Spartina* (Vadegraes) i Horsens Fjord. (New site for *spartina* in Denmark). *Flora Fauna* 80(2), 37-42. (*In Biol. Abstr.* 59(3), 1343).
- Agrios, G. N. (1969): *Plant Pathology*. 629 pp., Academic Press, New York.
- Ameson, E. and Stiers, D. L. (1977): *Cephalosporium gramineum*: A Seed-Borne Pathogen. *Plant Dis. Rep.* 61(8), 619-621.
- Apinis, A. E. and Pugh, G. J. F. (1967): Thermophilic Fungi of Birds' Nests. *Mycopathol. Mycol. Appl.* 33, 1-9.
- Ash, J. S., Jones, P. H. and Melville, R. (1961): The Contamination of Birds with Pollen and Other Substances. *Brit. Birds* 54, 93-100.
- Babbar, O. P., Shukla, U. S., Agnihotri, V. P. and Singh, K. (1976): Some New Aspects of Mycoplasmal Infections in



- Plants. Proc. Indian Natl. Sci. Acad. Part B, Biol. Sci. **41**(4), 373-378. In Biol. Abstr. **63**(8), 4617.
- Bell, D. K. and Sobers, E. K. (1966): A Peg, Pod, and Root Necrosis of Peanuts Caused by a Species of *Calonectria*. Phytopathology **56**, 1361-1364.
- Bray, W. L. (1910): The Mistletoe Pest in the Southwest. U. S. Dept. Agr. Bur. Plant Ind. Bull. No. 166., 39 pp.
- Broadbent, L. (1964): Control of Plant virus Disease, pp. 330-364. In Plant Virology (M. K. Corbett and H. D. Sisler, eds.), Univ. Florida Press, 527 pp., Gainesville, Fla.
- Broadbent, L. (1965): The Epidemiology of Tomato Mosaic. VIII-IX. Am. Appl. Biol. **55**(1), 57-69.
- Broadbent, L. and Martini, C. (1959): The Spread of Plant viruses. Advance. Virus Res. **6**, 93.
- Cleland, J. B. (1952): The Dispersal of Plants by Birds. South Australian Ornith. **20**, 72-77. In Biol. Abstr. **27**, 205.
- Cooney, D. G. and Emerson, R. (1965): Thermophilic Fungi. W. H. Freeman and Co., San Francisco, 188 pp.
- Cother, E. J. (1977). Isolation of Important Pathogenic Fungi from Seeds of *Cicer arietinum*. Seed Sci. Technol. **5**(3), 593-598.
- Cruden, R. W. (1966): Birds as Agents of Long-Distance Dispersal for Disjunct Plant Groups of the Temperate Western Hemisphere. Evolution **20**, 517-532.
- Davison, G. W. H. (1976): Role of Birds in Moss Dispersal. Brit. Birds **69**(2), 65-66.
- De Vlaming, V. and Proctor, V. (1968): Dispersal of Aquatic Organisms: Viability of Seeds Recovered from the Droppings of Captive Killdeer and Mallard Ducks. Am. J. Bot. **55**, 20-26.
- Evans, R. N. and Prusso, D. C. (1969): Spore Dispersal by Birds. Mycologia **61**(4), 832-835.
- Falla, R. A. (1960): Oceanic Birds as Dispersal Agents. Roy. Soc. London Proc. Ser. B, Biol. Sci. **152**(949), 655-659.
- Ferner, D. S. and King, J. R. (1972): Avian Biology. Vol. II. Academic Press, Inc., New York, 612 pp.
- Fordham, A. J. (1969): Seed Dispersal by Birds and Animals in the Arnold Arboretum (Harvard University). Arnoldia **27**(10/11), 73-84.
- Garren, K. H.: Beute, M. K. and Porter, D. M. (1972): The Cylindrocadium Black Rot of Peanuts in Virginia and North Carolina. Am. Peanut Res. Educ. Assoc., Inc. **4**(1), 67-71.
- Gilliam, M. (1972): Fungi Isolated from the Intestinal Contents of Foraging Worker Honeybees, *Apis mellifera*. J. Invertebr. Pathol. **20**(1), 101-103.
- Hanlin, R. T. (1973): The Distribution of Peanut Fungi in the Southeastern U.S.A. Mycopathol. Mycol. Appl. **49**(4), 227-241.
- Hasan, S. (1976): Study of the Passage of a Plant Pathogen Fungus, *Colletotrichum lagenarium* Through the Gut of *Euparypha pisana*. Ann. Zool. Ecol. Anim. **8**(2), 221-230. In Biol. Abstr. **63**(7), 4061.
- Heald, F. D. (1943): Introduction to Plant Pathology. McGraw-Hill, New York, 603 pp.
- Heald, F. D. and Studhalter, R. A. (1914): Birds as Carriers of the Chestnut-Blight Fungus. J. Agric. Res. **11**, 405-422.
- Hiller, R. B. (1978): The Role of Birds in Spreading the Cylindrocadium Black Rot of Peanuts. M. S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, 116 pp.
- Hubalek, Z. (1972): Keratinophile Pilze an Freilebenden Voegeln. (Keratinophilic Fungi on Wild Birds). Mykosen. **15**(5), 207-211. In Biol. Abstr. **55**(8); 4527.
- Hubalek, Z. (1974): Dispersal of Fungi of the Family Chaetomiaceae by Free-Living birds: I. A. Survey of Records. Ceska. Mycol. **28**(2), 65-79. In Biol. Abstr. **58**(12), 6984.
- Hubalek, Z. (1976): Seasonal Distribution of Fungi on House Sparrows. Trans. Br. Mycol. Soc. **66**(3), 509-516.
- Ingold, C. T. (1953): Dispersal of Fungi. Oxford University Press, London, 197 pp.
- Janzen, D. H. (1971): Seed Predation by Animals. Ann. Rev. Ecol. Systematics **2**, 465-492.
- Johnston, J. R. (1912): The History and Cause of the Coconut Bud-Rot. U.S.D.A. Bur. Plant Ind. Bull. No. 228, 175 pp.
- Kocan, R. M. and Hasenclever, F. (1974): Seasonal Variation of the Upper Digestive Tract Yeast Flora of Feral Pigeons. J. Wildl. Dis. **10**, 263-266.
- Kouyeas, V. and Anastassiadis, B. (1962): Dissemination of *Deuterophoma tracheiphila* Petri by the Common Magpie (*Pica pica* L.). Kiphissia. Ann. Inst. Phytopathol. Benaki, N.S. **4**, 52-55.
- Krefting, L. W. and Roe, E. I. (1949): The Role of Some Birds and Mammals in Seed Germination. Ecol. Monogr. **16**, 269-286.
- Lachmund, H. G. (1929): *Cronartium comptoniae* (Arth.) in Western North America. Phytopathology **19**, 453-466.
- Malone, C. R. (1965): Dispersal of Plankton: Rate of Food Passage in Mallard Ducks. J. Wild. Manage. **29**(3), 529-533.
- Malone, C. R. (1966): Regurgitation of Food by Mallard Ducks. Wilson Bull. **78**(2), 227-228.
- Monga, D. P. (1971): Prevalence of Pathogenic Fungi in Wild Birds. Indian J. Med. Res. **60**, 517-519.
- Nielson, O. (1929): Bekampfung des Kartoffelkresbsses (*Synchytrium endobioticum*) in Danemark. Nord. Jordbrugsforsk **7**, 549. In Rev. Appl. Mycol. **9**, 670).
- Nik, W. Z. and Parbery, D. G. (1977): Studies of Seed Borne Fungi of Tropical Pasture Legume Species. Aust. J. Agric. Res. **28**(5), 821-842.
- Olson, S. L. and Blum, K. E. (1968): Avian Dispersal of Plants in Panama. Ecology **49**(3), 565-566.
- Peplinski, J. D. and Merrill, W. (1974): Nonsurvival of *Ceratocystis fagacearum* in Frass of Oak Bark Beetles and Ambrosia Beetles. Phytopathology **64**(12), 1528-1530.
- Proctor, V. W. (1959): Dispersal of Freshwater Algae by Migratory Water Birds. Science **130**(3376), 623-624.
- Proctor, V. W. (1964): Viability of Crustacean Eggs Recovered from Ducks. Ecology **45**(3), 656-658.
- Proctor, V. W. (1968): Long Distance Dispersal of Seeds by Retention in Digestive Tract of Birds. Science **160**(3825), 321-322.
- Pugh, G. J. F. (1964): Dispersal of *Arthroderma curreyi* by Birds, and Its Role in the Soil. Sabouraudia **3**, 275-278.
- Pugh, G. J. F. (1965a): Fungi Recorded on Birds from Stockholm. Rep. Stokholm Bird Observ., pp. 21-24.
- Pugh, G. J. F. (1965b): Cellulytic and Keratinophilic Fungi Recorded on Birds. Sabouraudia **4**, 85-91.
- Pugh, G. J. F. (1966a): Associations Between Birds' Nests, Their pH, and Keratinophilic Fungi. Sabouraudia **5**, 49-53.
- Pugh, G. J. F. (1966b): Fungi on Birds in India. J. Indian Bot. Sci. **45**(3/4), 296-303. In Biol. Abstr. **50**(23/24), 12367.
- Pugh, G. J. F. (1972): The Contamination of Birds' Feathers by Fungi. Ibis **114**(2), 172-177.
- Pugh, G. J. F. and Evans, M. D. (1970): Keratinophilic Fungi Associated with Birds: I. Fungi Isolated from the Feathers, Nests and Soils. Trans. Brit. Mycol. Soc. **54**(2), 233-240.
- Reitsma, J. and Van Emden, J. H. (1949): De Bladpokkenziekte van de Thee. (The Blister-Blight of Tea). Bergcultures. **12**, 218-231 and **18**, 370-377. In Rev. Appl. Mycol. **29**, 58.
- Schlichting, H. E. (1960): The Role of Waterfowl in the Dispersal of algae. Trans. Am. Microsc. Soc. **79**, 160-166.
- Shaw, D. E. (1965): Condition Resembling Blister-Blight of Tea on Tea Seedlings in Quarantine in New Guinea. F. A. O. Plant Protect. Bull. **13**, 56-64.
- Sheridan, J. E. (1977): *Drechslera* spp. and Other Seed-Borne Pathogenic Fungi in New Zealand Cereals. New Zealand J. Agric. Res. **20**(1), 91-94.
- Sigurdsson, H. and Fridriksson, S. (1969): Birds and Seed Dispersal over Long Distances. Plants and Gard. **25**, 54.
- Sladen, W. J. L. and Austwick, P. K. C. (1955): The Mycoflora of Wild Pink Footed Geese Sampled in Iceland and Scotland, 1953, pp. 133-138. In the Wildfowl Trust 1953-1954 (P. Scott and H. Boyd, eds.), Country Life, Ltd., London, 235 pp.
- Sturkie, P. D. (1976): Avian Physiology. Springer-Verlag, Inc., New York, 400 pp.
- Tiffany, L. H.; Gilman, J. C. and Murphy, D. R. (1955): Fungi from Birds Associated with Wilted Oaks in Iowa. Iowa State



- Coll. J. Sci. **29**, 659-706.
- Tiunina, E. V. (1931): (Life Cycle of Yeast). Tr. Sev. Kav. Inst. Spetsial. Nyk. Tekhnicheskikh Kultur. **1**(1), 101-127. *In Biol. Abstr.* **8**(1), 163.
- Trykoz, H. O. (1975): Spores of Fungi in Nests of Muridae Rodents, on Gamasoids, Fleas and Lice. *Ukranian Bot. Zh.* **32**(5), 603-611. *In Biol. Abstr.* **64**(4), 2236.
- Warner, G. M. and French, D. W. (1970): Dissemination of Fungi by Migratory Birds: Survival and Recovery of Fungi from Birds. *Can. J. Bot.* **48**, 907-910.
- Zilka, P. J. and Tinnin, R. O. (1976): Potential Avian Influence in the Distribution of Dwarf Mistletoe. *Northwest Sci.* **50**(1), 8-16.

# Competitive Interaction Between Two Mountain Lake Crayfish Species with Life History Notes

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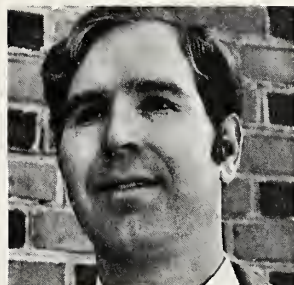
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**Abstract**—Using laboratory experiments, we tested the hypothesis that *Orconectes spinosus* (Bundy) is more aggressive than *Cambarus bartonii bartonii* (Fabricius) and able to outcompete the latter for shelter, as a potential explanation for the displacement of *C. bartonii* by *O. spinosus* in Mountain Lake, Virginia. In direct aggressive encounters and in competition for shelter, however, *O. spinosus* showed no advantage over *C. bartonii*; in most cases an advantage favoring *C. bartonii* was found. Notes on life history are included. Differences in the timing of reproduction in the two species do not give any obvious competitive advantage.

## Introduction

Prior to 1933, the only crayfish species known from Mountain Lake, near Blacksburg, Virginia, was *Cambarus bartonii bartonii* (Fabricius), which was common at that time (Hobbs and Walton, 1965). In that year *Orconectes spinosus* (Bundy)<sup>1</sup> was in-

troduced to the lake; by 1957 it was abundant and had completely displaced *C. bartonii*, although the latter still occurs in nearby streams, including the one draining the lake. Hobbs and Walton (1965) documented this change but offered no conclusive explanation of it. They suggested that life history might be important in that *O. spinosus* apparently reproduced earlier in the year than *C. bartonii*, possibly giving the young a competitive advantage. However, data on the life history of both species are extremely meager.

Competitive exclusion, involving a variety of mechanisms, has been suggested as an explanation for several of the observed distribution patterns among crayfish (Rhoades, 1944; Eberly, 1960; Penn and Fitzpatrick, 1963; Aiken, 1965; Fitzpatrick, 1967; Crocker and Barr, 1968; Bovbjerg, 1970; Capelli, 1975). In some cases (Penn and Fitzpatrick, 1963; Bovbjerg, 1970), direct aggressive interaction between species has been suggested as an important competitive mechanism maintaining existing distribution patterns or allowing species displacements. In these studies, evidence for the importance of aggressive interactions has been based on laboratory experiments involving direct "fight" type encounters, or competition for resources such as substrate, in highly simplified environments. In a similar study (manuscript in preparation), we have found that *Orconectes rusticus*, which is displacing *O. virilis* and *O. propinquus* in Wisconsin (Capelli, 1975), is by far the better competitor. Thus, results from these various laboratory studies have been consistent with what might be predicted on the basis of field observations.

We describe here the results of laboratory studies of aggressive interactions and competition for shelter between *C. bartonii* and *O. spinosus*. Notes on life history, based on collections in the Mountain Lake area, are also included.

## Collecting Areas

Mountain Lake, the main collecting area for *O. spinosus*, is an oligotrophic drainage lake (area = 0.2

<sup>1</sup> In the past, the *Orconectes* species in Mountain Lake has been referred to *O. juvenilis* (Hagen). However, H. H. Hobbs, Jr. (U.S. National Museum, Wash., D. C., pers. comm.) has determined that the Mountain Lake species is not *O. juvenilis*, and suggests that it be referred to *O. spinosus* pending further study.



km<sup>2</sup>, maximum depth = 31.5 m, elevation = 1180 m) located on Salt Pond Mountain approximately 15 km from Blacksburg, Virginia. Its basic limnological characteristics have been described in Roth (1963), Roth and Neff (1964), Parker, Wolfe, and Howard (1975), and Dubay (1976). Some *O. spinosus* were also collected in nearby Silvatica Pool, a 100-m<sup>2</sup> spring-fed pond.

*Cambarus bartonii* were collected in Hunters Branch and Pond Drain; both are fast-flowing rocky streams, with the latter draining Mountain Lake.

### Materials and Methods

Crayfish were collected by seining or dip-netting from August through October 1977. Only adults were used as determined by a carapace length > 20 mm (the minimum observed size for form I males<sup>2</sup> and egg-bearing females in both species). Prior to experimentation, individuals were maintained in laboratory aquaria for at least 48 hours at room temperature; species were not mixed during this time.

In all competition experiments, a crayfish pair consisting of an individual from each species was observed in a 20-cm diameter glass bowl with 3-cm water depth. The size difference between paired crayfish was always < 1 mm carapace length. Continuous dim room lighting was maintained for the 24- to 48-hour duration of each experiment. Food was not present. Within each experiment, individuals were not used in more than one trial.

The following experiments were designed to test the hypothesis that *O. spinosus* is more aggressive than *C. bartonii* and able to outcompete the latter for shelter (a potentially important resource for crayfish).

**Experiment 1: Aggressive Interactions in the Absence of Shelter.**—Each crayfish pair was placed in a bowl and allowed 24 hours to acclimate to the experimental habitat. Data on aggressive interactions were then taken for 30 minutes or until 5 interactions had occurred. Interactions were classified as threat, strike, or fight, following the method used by others (Penn and Fitzpatrick, 1963; Bovbjerg, 1970). For each pair, a "winner" was determined as follows: if no fights occurred, threats were assigned a value of "1" and strikes a value of "2," with the winner determined on the basis of highest point total. Most pairs, however, exhibited 1 to 5 fights during the observation period. The "loser" of a fight could be easily determined on the basis of disengagement from the fight followed by avoidance. The winner for the pair was determined on the basis of number of fights won.

**Experiment 2: Competition for Shelter.**—A shelter made from a plastic tumbler (length = 10 cm, radius = 3 cm) cut in half lengthwise was placed in each bowl. Dimensions were such that two crayfish could not occupy the shelter without being in physical contact. The following three tests were run: (1) to determine shelter preference in each species, single crayfish

were placed in the bowls. After 24 hours crayfish were recorded as either in or out of the shelter. (2) Pairs consisting of an individual of each species were placed in the bowls. After 24 hours crayfish were recorded as either in or out of the shelter, and (3) A single crayfish was placed in each bowl. After 24 hours an individual of the other species was added. After an additional 24 hours, crayfish were recorded as either in or out of the shelter.

Our hypothesis that *O. spinosus* has a competitive advantage over *C. bartonii* in these kinds of tests predicts that the number of trials "won" by *O. spinosus* should be significantly higher than the number expected if the probability of a "win" were only 0.5. We classified results of our trials as "win" or "not win" for *O. spinosus*; using a binomial distribution, we tested for significant deviation from the number of expected "wins" if the probability were 0.5.

### Results

Simple inspection of the data (Tables 1-5) reveals no evidence that *O. spinosus* is more aggressive than *C. bartonii* or able to outcompete the latter for shelter under our experimental conditions. In aggressive interactions in the absence of shelter, *C. bartonii* won more encounters than *O. spinosus* in all combinations except when form I *O. spinosus* were paired with form II *C. bartonii* (Table 1). However, even in this case the number of *O. spinosus* wins was not significantly greater ( $p = 0.4$ ) than that expected if the probability of a win were only 0.5.

TABLE 1

Results of aggressive interactions between *O. spinosus* and *C. bartonii* in the absence of shelter. Os = *O. spinosus*, Cb = *C. bartonii*

Os	Cb	Trials	Os Wins	Cb Wins	Ties
male I	male I	26	7	17	2
male II	male II	12	3	7	2
female	female	25	10	11	4
male II	male I	3	0	3	0
male I	male II	23	12	7	4
TOTALS		89	32	45	12

Both species, and all sexual forms within species, showed a similar high preference for shelter under our experimental conditions (Table 2). In most cases, crayfish occupied the shelter almost immediately after being placed in the bowl. Data were taken only once after 24 hours; however, most crayfish appeared to occupy the shelter most of the time for several hours prior to the end of the 24-hour period.

When both crayfish were placed in the bowl at the same time, both were commonly found occupying the shelter at the same time after 24 hours (Table 3). In cases where only one occupied the shelter, *C. bartonii* was the species in the shelter most of the time.

When *C. bartonii* was given a 24-hour advantage before the introduction of *O. spinosus*, *O. spinosus* occupied the shelter to the exclusion of *C. bartonii* only 7 times in 36 trials (Table 4). When *O. spinosus* was given the 24-hour advantage, the number of sole occupancies by *O. spinosus* increased to 18 in 36 trials (Table 5), still not significantly different from that

<sup>2</sup> In most crayfish species, the adult males alternate via molts between two recognizable morphological forms, known as form I and form II. The most conspicuous differences between the two involve the anatomy of the copulatory stylet. Mating occurs only in form I; such individuals are also generally considered to be more aggressive than those in form II.

TABLE 2

Shelter preference in *O. spinosus* and *C. bartonii*, based on the number of individuals which were in shelters after 24 hours

	<i>Os</i>		<i>Cb</i>	
	Trials	In Shelter	Trials	In Shelter
male I	5	4	5	3
male II	20	17	13	13
female	15	12	22	19
TOTALS	40	33	40	35

expected if the probability of sole occupancy were 0.5.

TABLE 3

Results of shelter competition when both species were placed in bowls at the same time

		SHELTER OCCUPANCY			
<i>Os</i>	<i>Cb</i>	Trials	<i>Os</i> Alone	<i>Cb</i> Alone	Both
male I	male I	16	4	8	4
male II	male II	5	1	2	2
female	female	23	2	7	14
male II	male I	6	1	3	2
male I	male II	13	3	5	5
TOTALS		63	11	25	27

### Notes on Life History

Periodic collections of both species were made during 1974-77, with all months of the year represented in the total effort. In August and September 1977, special efforts were made to collect immatures of both species.

TABLE 4

Results of shelter competition when *C. bartonii* was placed in bowl 24 hours prior to *O. spinosus*

		SHELTER OCCUPANCY			
<i>Os</i>	<i>Cb</i>	Trials	<i>Os</i> Alone	<i>Cb</i> Alone	Both
male I	male I	9	3	6	0
male II	male II	8	0	0	8
female	female	7	0	1	6
male II	male I	4	0	4	0
male I	male II	8	4	0	4
TOTALS		36	7	11	18

Female *O. spinosus* with eggs were found only during March, April, and May. At times close to 100 percent of the adult females in the collections were berried. Female *C. bartonii* with eggs were found during May, September, and October. However, berried females never exceeded 21 percent of the adult females in collections at any time.

In August, mean size of immature *C. bartonii* in collections was identical to that of immature *O. spinosus* (Figure 1). In September, following the hatch of

new young-of-year *C. bartonii*, the mean size of immature *C. bartonii* declined, while that of *O. spinosus* continued to increase.

TABLE 5

Results of shelter competition when *O. spinosus* was placed in bowl 24 hours prior to *C. bartonii*

		SHELTER OCCUPANCY			
<i>Os</i>	<i>Cb</i>	Trials	<i>Os</i> Alone	<i>Cb</i> Alone	Both
male I	male I	8	4	2	2
male II	male II	8	4	0	4
female	female	8	2	2	4
male II	male I	4	0	4	0
male I	male II	8	4	2	2
TOTALS		36	18	6	12

### Discussion

These studies do not support direct aggressive interaction as the mechanism responsible for the displacement of *C. bartonii* by *O. spinosus*. *Orconectes spinosus* generally did best when form I individuals competed with form II *C. bartonii*, or when given a 24-hour advantage in the shelter experiments (Tables 1,3,4,5). Even in these situations, however, *O. spinosus* never exhibited any great advantage. In other situations, *C. bartonii* maintained a consistent advantage.

Life history of *O. spinosus* is apparently similar to that reported for several other species in this genus, which typically have a specific time of year (usually spring or early summer) when eggs and young are produced (Andrews, 1904; Van Deventer, 1937; Capelli, 1975). *C. bartonii*, however, seems to be very irregular regarding the time of year when young are produced. Hobbs, Holt, and Walton (1967) found ovigerous *C. bartonii* in the Mountain Lake area only during June, July, and August. Of 75 adult females collected in these months during our study, however, none had eggs or young; our data suggest instead a bimodal (spring-fall) pattern. Other workers have found ovigerous females or newly hatched young at various times from February to November in this species (Crocker and Barr, 1968). Thus the egg-bearing period of *C. bartonii* appears to be extended and irregular, and probably variable from year to year in the same area.

It is not clear that these life history patterns would confer any advantage on *O. spinosus*. Although young-of-year *O. spinosus* might have an advantage because of their size over *C. bartonii* produced later in the year, the latter might be sufficiently smaller so as not to compete for the same resources. This would be more likely if the interval between the hatching periods were long (e.g. spring vs. fall). Or, assuming young *O. spinosus* do have an advantage because of their size when some *C. bartonii* hatch in the fall, the advantage would reverse or at least diminish the following spring when new *O. spinosus* would hatch in the presence of young *C. bartonii* produced late in the previous year. A species would most likely be at a competitive disadvantage if its young were all produced a short time after those of another species, so that both might be competing for approximately the



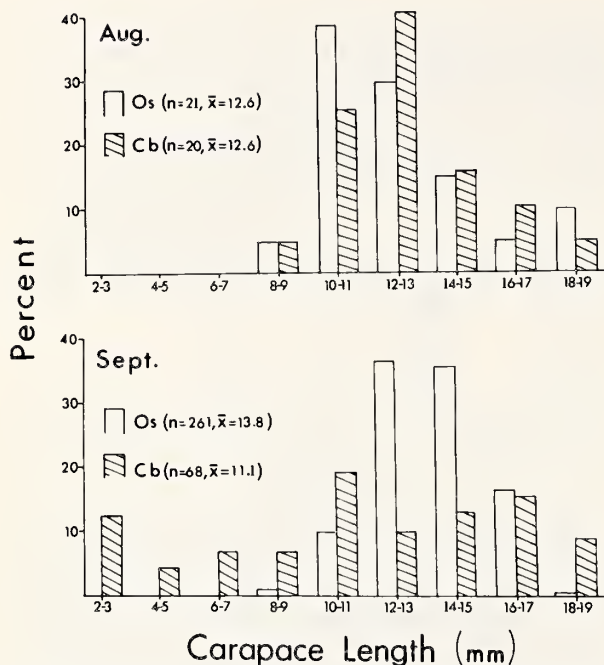


FIG. 1—Percent distribution of size classes of immature *O. spinosus* and *C. bartonii* collected during August and September 1977.

same resources but with one species maintaining a consistent size advantage throughout a whole growing season.

Data on size of young-of-year may not be completely comparable because the two species were collected in different habitats. However, data for August suggest that young *C. bartonii*, whether produced the previous fall or spring, would have had no size disadvantage in comparison to *O. spinosus* during most of the growing season.

The elimination of *C. bartonii* by *O. spinosus* in Mountain Lake is not adequately explained by the simple competitive mechanisms suggested by other studies and tested here. The mechanisms by which one species derives an advantage over another may involve a variety of subtle but significant differences not easily tested in a simplified laboratory environment. For example, Hobbs (personal communication), on the basis of egg counts in the two species, suggests that *O. spinosus* may have a significantly greater reproductive potential than does *C. bartonii*. The results of our shelter experiments suggest that *O. spinosus* would have no advantage in competition for resources when direct physical interaction with the other species is involved. However, we do not know whether shelter is in fact an important resource under natural conditions for the adults tested here, nor the

extent to which it might be lacking. A much more detailed knowledge of the life history and autecology of each species will be necessary to explain the displacement.

### Acknowledgments

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### Literature Cited

- Aiken, D. E. (1965): Distribution and Ecology of Three Species of Crayfish from New Hampshire. *Am. Midl. Nat.* **73**, 240-244.
- Andrews, E. A. (1904): Breeding Habits of Crayfish. *Am. Nat.* **38**, 165-206.
- Bovbjerg, R. V. (1970): Ecological Isolation and Competitive Exclusion in Two Crayfish (*Orconectes virilis* and *Orconectes immunitis*). *Ecology* **51**, 225-236.
- Capelli, G. M. (1975): Distribution, Life History, and Ecology of Crayfish in Northern Wisconsin, with Emphasis on *Orconectes propinquus* (Girard). Ph.D. thesis, U. of Wisconsin, Madison, 215 pp.
- Crocker, D. W. and Barr, D. W. (1968): Handbook of the Crayfish of Ontario. U. of Toronto Press, 158 pp.
- Dubay, C. I. (1976): The Standing Crop and Distribution of Macrophytes in Mountain Lake, Virginia, with Particular Emphasis on the Contribution of *Nitella flexilis* (L.) AG. to the Metalimnetic Oxygen Maximum. Master's thesis, U. of Virginia, 97 pp.
- Eberly, W. R. (1960): Competition and Evolution in Cave Crayfish of Southern Indiana. *Syst. Zool.* **9**, 29-32.
- Fitzpatrick, J. F., Jr. (1967): The *propinquus* Group of the Crayfish Genus *Orconectes* (Decapoda: Astacidae). *Ohio J. Sci.* **67**, 130-172.
- Hobbs, H. H., Jr. and Walton, M. (1965): *Orconectes juvenilis* (Hagen) in Mountain Lake, Virginia: An Unplanned Experiment in Interspecific Competition (Decapoda, Astacidae). *Va. J. Sci.* **17**, 136-140.
- Hobbs, H. H., Jr.; Holt, P. C. and Walton, M. (1967): The Crayfishes and Their Ostracod and Branchiobdellid Associates of the Mountain Lake, Virginia, Region. *Proc. U. S. Nat. Mus.* **123**(3602), 84 pp.
- Parker, B. C.; Wolfe, H. E. and Howard, R. V. (1975): On the Origin and History of Mountain Lake, Virginia. *Southeast. Geol.* **16**, 213-226.
- Penn, G. H. and Fitzpatrick, J. F., Jr. (1963): Interspecific Competition Between Two Sympatric Species of Dwarf Crayfishes. *Ecology* **44**, 793-797.
- Rhoades, R. (1944): The Crayfishes of Kentucky with Notes on Variation, Distribution, and Descriptions of New Species and Subspecies. *Am. Midl. Nat.* **31**, 111-149.
- Roth, J. C. (1963): Studies of Mountain Lake, Virginia. Master's thesis, Virginia Polytechnic Institute and State U., 95 pp.
- Roth, J. C. and Neff, S. E. (1964): Studies of Physical Limnology and Profundal Bottom Fauna, Mountain Lake, Virginia. *Virginia Agric. Exp. Stn. Tech. Bull.*, No. 169., 44 pp.
- Van Deventer, W. C. (1937): Studies on the Biology of the Crayfish *Cambarus propinquus* Girard. *U. Ill. Bull.* **34**, 1-67.

# On Certain Atmospheric Characteristics of the Tidewater Area\*

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**Abstract**—The paper describes three specific features of the atmospheric environment in Tidewater, Virginia: (1) the nature of atmospheric stability and large-scale prevailing winds; (2) the behavior of shopping centers as mini-urban heat islands; and (3) trends in visibility statistics as indicators of air pollution level. The impact of these studies on the Tidewater area as an airtight reservoir for air pollutants is discussed.

## Introduction

There is a strong contrast between the weather in a city and that in the neighboring area. This inadvertent modification of weather introduced by cities results in higher temperatures, milder and less gusty winds, lower relative humidity but increased cloud cover and rainfall, more frequent occurrence of fogs and severe storms, more frequent and longer lasting thunderstorms, and poorer air quality. Table 1 lists

the typical urban-rural contrasts in elements of weather. These effects have been studied for several decades. Rising concerns about the quality of city air have led to more intensive studies in recent years. A five-year study of the St. Louis area under the project METROMEX (Metropolitan Meteorological Experiment) confirms the listed effects. The city of St. Louis is 1 to 3 C warmer and receives 40 percent more rain and 60 percent more thunderstorms than its surroundings.

The urban-rural temperature contrast is typically a few degrees, but extremes of 14 C and 20 C have been recorded for Berlin and Montreal. These increased temperatures, known as the "urban heat islands," are due to the higher thermal capacity of city structures and additional industrial, domestic, and automotive sources of heat.

The colder and moister air from the countryside warms as it penetrates the city, rises due to buoyancy, and cools as it ascends, leading to circulation patterns shown in Figure 1. This convective circulation is further enhanced by the orographic effect of tall buildings and sky scrapers which increase cloud cover and precipitation as the air attains the saturated state. Aerosols (particulates) act as nuclei of condensation. Their ready availability is responsible for more frequent occurrence of *light* (0.5 to 1.6 km) and *moderate* (100 to 500 m) fogs in cities, and *dense* or *advective* fogs (< 100 m) in the suburbs. Moisture and particulates in air have a profound effect on visibility.

Shopping centers located within an urban area may produce a significant heat island effect and other related phenomena. This is particularly the case for shopping centers having sharp boundaries (thermal contrasts) with the surrounding residential areas. Among the causes for the shopping center effect are the uneven solar heating of the shopping center and surrounding areas, greater evaporation of water from plants and trees in residential and recreational areas, and the larger concentration of air-conditioning units, automobiles and people in the shopping center. Similar or reverse effects may be introduced by other activity centers, parks, and lakes. Therefore, a better understanding of the cause-effect relationships pertaining to the urban environment should be helpful in improved urban design.

The research described here originated in an invited paper (Chopra, 1971) presented to the Fluid Dynamics Division of the American Physical Society. The Tidewater area is a natural laboratory for studies in urban environment for several reasons:

\* An updated version of various papers presented at the annual meetings of the Virginia Academy of Science during 1971-75. The abstracts appeared in Va. J. Science 22, 117 (1971); 23, 131 and 157 (1972); 25, 58 and 121 (1974); and 26, 82 (1975).

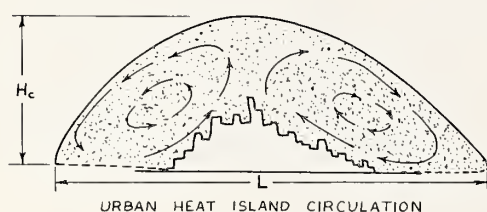


TABLE I  
Weather Modification Introduced by Cities

Weather Element	Comparison with Rural Environment
Temperature	
Annual mean	0.5 to 1.0°C higher
Winter minimum	1.0 to 2.0°C higher
Relative humidity	
Annual mean	6% lower
Winter mean	2% lower
Summer mean	8% lower
Cloud cover	5 to 10% more
Fogs (Summer)	
Light	5 to 8 times more frequent
Moderate	50% more frequent
Dense	30 to 50% more frequent
Fogs (Winter)	
Light	6 to 10 times more frequent
Moderate	80% more frequent
Dense	100% more frequent
Precipitation (Total)	5 to 10% more
Winds	
Annual mean speed	20 to 30% less
Extreme gustiness	10 to 20% less
Calm winds	5 to 20% more frequent

1. Tidewater (Hampton Roads) is a coastal region, bordering on the Atlantic Ocean, in the south-eastern corner of Virginia. It consists of four contiguous cities with no significant concentration of heavy industry. At the time of our initial study, the rural and suburban areas were better defined and clearly separable from Federal (principally naval installations), industrial and urban areas (Fig. 2). Therefore, a study of this area would help in our improved understanding and better establishment of cause-effect relationships concerning the coastal-urban environment.
2. The region is experiencing rapid growth and, therefore offers a potential for immediate application of the results of the study to its future development.

URBAN HEAT ISLAND



AIR FLOWS OVER CANOPY IF  $H_c < h_c = \frac{Du_0}{LJ}$

AIR FLOWS AROUND CANOPY IF  $H_c > h_c = \frac{Du_0}{LJ}$

FIG. 1—Circulation of air under an urban canopy.

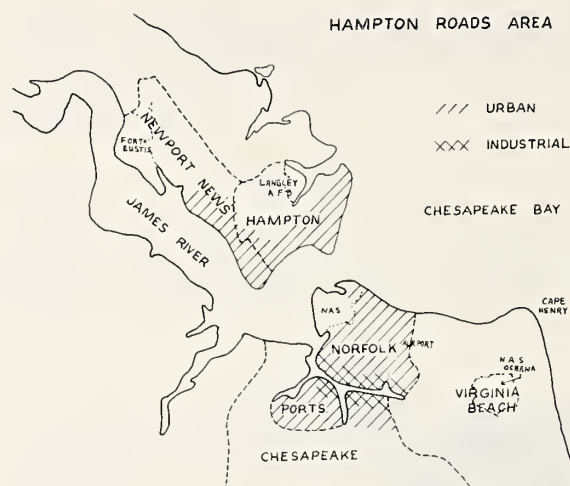


FIG. 2—Geographical map of the Tidewater (Hampton Roads) area.

This paper treats the following aspects of the atmospheric environment at Norfolk, one of the four cities in the Hampton Roads area:

1. The pattern of prevailing winds and atmospheric stability as to their effectiveness in dispersing air pollutants and hence improving visibility.
2. Statistical analysis of the visibility data and its correlation with weather elements, like rainfall, to determine whether a trend in visibility is a reliable measure of the trend in air quality.
3. Heat island effects introduced by two neighboring shopping centers in Norfolk.

### Wind Patterns and Atmospheric Stability

The influence of an air pollutant depends on its chemical and physical properties, size, and concentration. The particle concentration is related to air space occupied by air pollutants. The nature of atmospheric stability and character of the prevailing winds have important bearing on mixing space available to pollutants.

The height of the base of the low lying thermal inversion may be used as the vertical dimension for estimating the mixing volume. The atmospheric lapse rate, which characterizes instability of the atmosphere, also determines the extent of vertical motions and, hence, the height of the inversion layer. Lower concentration of particulates and better visibility are expected to accompany an elevated inversion layer.

Wind speed, direction and gustiness are characteristics which influence the effectiveness of winds in the mixing process and in the extension of the mixing volume. Through transportation of air, winds extend the horizontal dimension of air pollutant mixing space. Gustiness determines the turbulent dispersal efficiency of pollutants in the horizontal and vertical crosswind directions. Since gustiness increases with wind speed, winds tend to dilute the concentration of air pollutants.

The annual distribution of wind directions (Table 2) and frequency of Pasquill stability classes (Table 3)

TABLE 2  
Annual Distribution of Wind Directions

Wind Direction	Distribution (%)
N	9.1
NNE	7.1
NE	5.6
ENE	6.6
E	7.1
ESE	3.0
SE	3.9
SSE	5.8
S	9.1
SSW	10.5
SW	6.2
WSW	5.7
W	7.5
WNW	4.0
NW	3.7
NNW	5.1
All Directions	100.0

are based on the hourly data recorded at the Norfolk Naval Air Station between December 1966 and November 1971. These features are also illustrated by the annual stability wind rose for the Tidewater area (Fig. 3). The wind data recorded at this weather station is regarded as representative for the Hampton Roads area. It appears that, on an annual basis, there is *no preferred prevailing wind direction* at Norfolk.

The regional atmosphere at Norfolk displays a generally high stability; this is not usual for an urban area. Because of greater surface roughness and higher temperature environment of cities as compared with rural areas, Pasquill stability class C (slightly unstable) normally characterizes an urban atmosphere. *It is significant that at Norfolk, stability classes D (neutral) and E (stable) account for 79 percent of all occurrences.*

The Tidewater area is regarded as lying in the so-called climatological shelter zone. The reasons for the high stability of air at Norfolk are mainly geographical. The midlatitude region forms a valley on a peninsula which adjoins the Atlantic Ocean. The adjoining water mass, with low surface roughness, enhances the stability of air passing over it and thus reduces the urban effect. Perhaps the Taylor column theory can better explain the region's atmospheric stability. In any case, a *stable* atmosphere is *not conducive to rapid dispersal* of air pollutants, and *lack of any preferred wind direction* merely leads to the *recycling* of air pollutants.

TABLE 3  
Annual Frequency of Pasquill Stability Classes

Stability class	Symbol	Frequency (%)
Extremely unstable	A	3
Unstable	B	7
Slightly unstable	C	12
Neutral	D	47
Stable	E	32
All classes		100

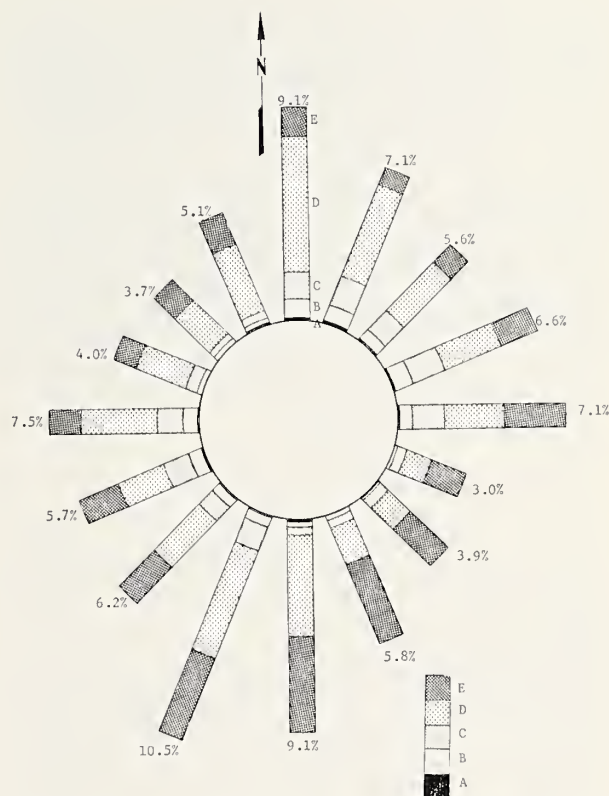


FIG. 3—Annual stability wind rose for the Tidewater area (December 1966–November 1971): A . . . extremely unstable; B . . . moderately unstable; C . . . slightly unstable; D . . . neutral; and E . . . stable.

### Visibility

*Visibility* is the term commonly used to indicate how far one can see. It may be argued that this term is rather indefinite and perhaps should be replaced by a much less frequently used but more precise term, "visual range" which specifies the maximum distance at which some particular object can be seen. However, the use of *visibility* continues to be standard practice in the literature of meteorology. The Glossary of Meteorology<sup>1</sup> gives the following definition:

"*Visibility*: In United States weather observing practice, the greatest distance in a given direction at which it is just possible to see and identify with the unaided eye (a) in the daytime, a prominent dark object against the sky at the horizon, and (b) at night, a known, preferably unfocused, moderately intense light source. After visibilities have been determined around the entire horizon circle, they are resolved into a single value of prevailing visibility for reporting purposes."

It is clear from the above definition that visibility is determined by visual observation with the naked eye. Transmissometer measurements may be reported by a weather station as additional information, but they

<sup>1</sup> Huschke, R.E., ed. (1959): Glossary of Meteorology. Am Meteorol. Soc., Boston, Mass.



do not replace the standard visual data. Also, reported visibility is not associated with a particular direction but is a composite value for the entire horizon. This composite is termed "prevailing visibility." Visibility values recorded by National Weather Service and military weather stations are prevailing visibilities. The standard procedure for determining prevailing visibility is described in the Manual of Surface Observations<sup>2</sup> used by United States weather observers. The horizon is divided into sectors of equal size such that the visibility is approximately constant in each sector. The prevailing visibility is taken as the highest visibility which is equaled or exceeded over at least half of the horizon, but not necessarily in contiguous sectors. Therefore, the visibility around at least half of the horizon is greater than or equal to the reported prevailing visibility.

Visibility is measured by an observer who looks around the horizon and determines which of a set of known objects or lights he can see. Such measurements are obviously influenced by subjective factors. However, the present procedure seems to be the best available method of arriving at a single visibility value.

The present practice of reporting prevailing visibility has been in effect since January 1, 1939. Before that time, the visibility value recorded was the maximum visibility in any direction around the horizon at the weather stations. This change in definition must be accounted for in studies using long-term historical visibility data.

In addition to prevailing visibility values, the records of a weather station contain other information in the category of "Remarks" which may be significant in air pollution studies. Whenever a visibility of less than 11.3 km (7 mi) is recorded, an explanation must be given under "Remarks." The reason may be precipitation (rain, snow, etc.) or an "obstruction to vision" (fog, smoke, haze, etc.). Haze notations are of particular interest. However, weather observers in urban areas find it difficult to distinguish between smoke and haze. For this reason, smoke and haze may both be listed. Experienced observers can usually distinguish between fog and haze.

Many weather stations record visibility at hourly intervals. Visibility values are reported in statute miles at land stations. It frequently happens that a weather station does not have suitable markers or lights for determining visibilities beyond 24 km (15 mi). For these stations, visibilities greater than 24 km (15 mi) are recorded as 15+. This procedure must be accounted for in analyzing visibility data.

A difficulty in the use of visibility data in urban air pollution studies is that most visibility measurements are made at airports. Since airports tend to be located on the outskirts of urban areas, reported values of prevailing visibility may not give sufficient weight to the visibilities in the directions of the congested urban centers.

The analysis of visibility data is complicated by the fact that visibility is affected by several meteorological factors as well as by air pollutants. The re-

duction in visibility due to air pollution is often associated with air particulates. This reduction is due to scattering and absorption of light by airborne particles. Gaseous pollutants are usually invisible or concentrated too low to affect visibility. However, when in sufficiently large concentrations, some triatomic gases may produce changes in sky color. A high concentration of NO<sub>2</sub>, for example, causes a characteristic brownish discoloration of the sky.

Moisture in the air influences visibility in two ways: (1) A water molecule is triatomic; it refracts, or scatters certain wavelengths. (2) Furthermore, when the relative humidity is high, hygroscopic particles absorb water and grow in size. Large particles are more effective in decreasing visibility. In coastal areas, the presence of sea salt particles in the atmosphere combined with high relative humidity may lead to low visibility conditions. This is possible even when there is a low atmospheric concentration of particulate matter which originated in urban settings. The transition of sea salt from a crystal to a liquid drop occurs at a relative humidity of 74 percent. A correlation between visibility and relative humidity based on data taken at the Los Angeles International Airport is shown in Fig. 4, (Neiburger and Wurtle, 1949). The sharp reduction in visibility for relative humidity values exceeding 70 percent is largely attributable to hygroscopic particles.

To a considerable extent, visibility depends on the air space available to air pollutants. As mentioned in the preceding section, better visibility conditions should be expected with elevated inversion layers and strong winds. Fig. 5 shows a correlation between wind speed and 0- to 16.1 km (0- to 10-mi) visibility in Bakersfield, California for daytime visibilities between 0730 and 1730 PST during May, July, September and November 1948-57 (Holzworth and Maga, 1960).

In cases where the atmospheric concentration of particulate matter is high, the visibility will exhibit a strong directional dependence. Even when the particle concentration is uniform, visibility will be lowest in the direction of the sun. This is because small particles scatter more light in the forward direction, i.e., away from the light source, than they scatter back toward the light source.

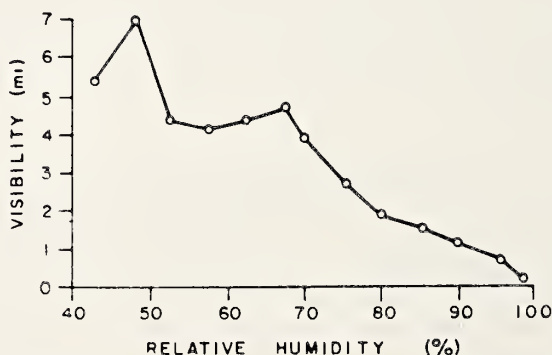


FIG. 4—Correlation between visibility and relative humidity at Los Angeles International Airport (after Neiburger and Wurtle, 1949).

<sup>2</sup> Manual of Surface Observations (1966). Circ. N. 7th Ed. U.S. GPO, Wash., D.C., 2-3.

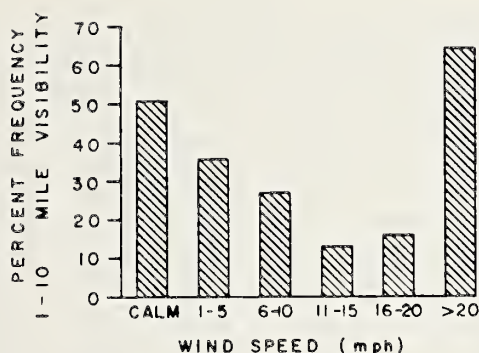


FIG. 5.—Effect of wind speed on visibility at Bakersfield, California (after Holzworth and Maga, 1960).

In addition to its dependence on atmospheric scattering and absorption of light, visibility is also limited by the ability of the eye to distinguish an object or light by its background contrast. The object-background contrast decreases as the object-to-observer distance increases. This occurs because the light intensity from the object along the observer's line of sight approaches the background light intensity. An object which is sufficiently far away that the observer cannot perceive a contrast between the object and its background is beyond the limit of visibility.

Whether expressed in terms of change in light intensity or alteration in object-background contrast, the effect of the atmosphere is due to scattering and absorption of light. The change in intensity  $dI$  of a light beam of intensity  $I(x)$  over a path length  $dx$  can be expressed as

$$dI = -\sigma dx \quad (1)$$

where  $\sigma$  is the extinction coefficient and the minus sign indicates the intensity decreases. If the distance from the object to observer is  $x$ , integration of equation (1) gives

$$I = I_0 \exp(-\sigma x) \quad (2)$$

where  $I_0$  is the intensity of light reflected by the object along the observer's line of sight and  $I$  is the light intensity at the eye of the observer. Similarly, the apparent contrast at a distance  $x$  from an object is

$$C = C_0 \exp(-\sigma x) \quad (3)$$

where  $C_0$  is the actual object-background contrast.

The extinction coefficient,  $\sigma$ , which includes both scattering and absorption effects, is related to the scattering coefficient  $\sigma_s$  and the absorption coefficient  $\sigma_a$  by  $\sigma = \sigma_s + \sigma_a$ . The value of the extinction coefficient is determined by all scattering and absorption processes occurring in the atmosphere. The problem of computing numerical values of  $\sigma$  in polluted atmospheres is simplified by the negligible contribution of gas molecules to the total light scattering. This molecular scattering is the well-known Rayleigh scattering. It is the dominant scattering mechanism for particles much smaller than the incident light wavelength. If molecular scattering was the limiting factor, visibilities of more than 161 km (100 mi) would be common.

Particulate air pollutants, whether in a liquid or solid state, normally occur as particles having sizes comparable to visible wavelengths. In this case, the appropriate scattering theory is designated as Mie scattering. The Mie scattering coefficient is

$$\sigma_{sm} = nk\pi R^2 \quad (4)$$

where  $n$  is the number of particles per unit volume and  $R$  is the particle radius. The scattering area parameter  $k$  is the area of the wave front acted on by the particle divided by the cross sectional area of the particle. The  $k$  factor depends on particle radius, the wavelength of the incident light, and the index of refraction of the particle.

For  $N$  types of particles,  $\sigma_{sm}$  can be written simply as

$$\sigma_{sm} = \sum_{i=1}^N \sigma_{smi} = \sum_{i=1}^N n_i k_i \pi R_i^2$$

if each type is of uniform size.

In general, both scattering and absorption effects must be considered in determining the extinction coefficient  $\sigma$ . However, for such common air pollutants as oil aerosols and submicron size particles resulting from incomplete combustion of hydrocarbon fuels, the absorption coefficient  $\sigma_a$  is small compared to the scattering coefficient  $\sigma_s$ . For dark-colored smoke and soot particles,  $\sigma_a$  cannot be neglected.

Data on extinction coefficients indicate that for a given mass of particulate matter, particles in the submicron size range are more effective than larger particles in reducing visibility. For example, the scattering effectiveness per unit mass of  $0.8\text{-}\mu$  water droplets is about 4 times that of  $2\text{-}\mu$  droplets.

Visibility can be readily calculated if the extinction coefficient is known. If the object used for the visibility measurement is assumed black, the contrast  $C_0$  in Eq. (3) has the value  $-1$ , and it becomes

$$C = -\exp(-\sigma x) \quad (6)$$

To obtain visibility from Eq. (6), it is necessary to specify the minimum contrast distinguishable by the eye. The limiting daytime contrast is generally taken as 0.02. Thus, when  $C = -0.02$  in Eq. (6), the distance  $x$  becomes the visibility  $V$ . Therefore

$$0.02 = \exp(-\sigma V) \quad (7)$$

and

$$V = 3.9/\sigma \quad (8)$$

The calculations leading to expression (8) for visibility  $V$  are based on the assumption that the extinction coefficient  $\sigma$  is constant along the line of sight between the observer and the object. This condition is generally satisfied since the atmosphere is usually homogeneous between the observer and the object; the illumination is uniform over this path length.

If the size and nature of the atmospheric particles are known, the concentration of particulate matter can be indirectly obtained from visibility measurements. The concentration  $C$  defined as the mass per unit volume is related to the particle concentration  $n$  by



$$C = (4\pi/3)R^3 n\rho \quad (9)$$

for spherical particles of uniform radius  $R$  and mass density  $\rho$ . If absorption of light is negligible compared to scattering, the extinction coefficient is given by Eq. (4) in terms of  $C$  as

$$\sigma = (3/4) kC/R\rho \quad (10)$$

Equations (8) and (10) can then be combined to give

$$C = 5.2\rho R/kV \quad (11)$$

As an example, for a water aerosol with droplets of 1.0- $\mu$  diameter,  $\rho = 1.0$  gm/cm<sup>3</sup>, and  $k = 3.9$ , the mass concentration associated with a visibility of 3.2 km (2 mi) is  $C = 2.0 \times 10^{-4}$  gm/m<sup>3</sup>.

It is apparent from Eq. (11) that the product  $VC$  is constant for atmospheric particles of a given type and size. This product is a measure of the total mass per unit area perpendicular to the line of sight between an observer and the limit of visibility. The value of  $VC$  for a water droplet of 1.0- $\mu$  diameter with  $k = 3.9$  is 0.67 g/m<sup>2</sup>.

In some cases airborne particles may be more effective in reducing visibility than ordinarily would be expected. This occurs with hygroscopic particles which can increase in size by absorbing water vapor from the air and act as condensation nuclei for atmospheric water vapor.

A low surface visibility due to air pollutants is now a common occurrence in many urban areas. In other cities where air pollution is not yet a serious problem, a significant decreasing visibility trend may serve as an early warning of an impending air pollution danger. In the late sixties and early seventies, declining visibility attributed to air pollution was reported at or near a number of urban areas. These include: Tuscan (Arizona) by Green and Battan (1967); Point Mugu (California) by Lea<sup>3</sup> (1970); Los Angeles (California) by Chass and Keith<sup>4</sup> (1971); Akron (Ohio), Lexington (Kentucky) and Memphis (Tennessee) by Miller et al. (1972); and Norfolk (Virginia) by Pritchard and Chopra (1972). The periods considered were 1949–65 by Green and Battan, 1949–69 by Lea, 1933–69 by Chass and Keith, 1962–69 by Miller et al., and 1960–70 by Pritchard and Chopra. The most pronounced effect observed by all these investigators was a *generally increasing trend in the frequency of low visibility*.

*Analysis of Visibility Data (1960–70) for Norfolk, Virginia*—Norfolk does not have a significant concentration of heavy industry, and therefore would not normally be expected to have air pollution problems. Nevertheless, persistent haze conditions, attributable to particulates in air, began to appear in 1965. Consequently, the period chosen for the study was an 11-year span from 1960 to 1970. The visibility data selected for statistical analysis were the visibilities measured at noon EST by the National Weather Service at Norfolk Regional Airport. The choice of data was made to facilitate comparison with the results ob-

TABLE 4  
Annual Visibility Indices for Norfolk (1960–70)

Year	km	$\bar{V}$ (mi)	km	$\sigma$ (mi)	S
1960	13.13	(8.16)	5.78	(3.59)	0.251
1961	13.21	(8.21)	5.68	(3.53)	0.228
1962	12.31	(7.65)	6.24	(3.88)	0.303
1963	13.57	(8.43)	6.52	(4.05)	0.197
1964	14.27	(8.87)	6.15	(3.82)	0.165
1965	12.46	(7.74)	6.20	(3.85)	0.363
1966	12.30	(7.64)	6.08	(3.78)	0.334
1967	13.18	(8.19)	6.36	(3.95)	0.182
1968	12.49	(7.76)	6.21	(3.86)	0.265
1969	12.50	(7.77)	6.12	(3.80)	0.067
1970	11.10	(6.90)	5.28	(3.28)	0.384

tained by Chass and Keith (1971) for Los Angeles.

Three statistical indices were computed for each set of yearly visible data. These indices for a set of  $N$  values are defined by

$$\bar{V} = \frac{1}{N} \sum_{i=1}^N V_i \quad (12)$$

$$\sigma = \frac{1}{N} \left[ \sum_{i=1}^N (V_i - \bar{V})^2 \right]^{1/2} \quad (13)$$

$$S = \frac{1}{N^3} \sum_{i=1}^N (V_i - \bar{V})^3 \quad (14)$$

where  $\bar{V}$  is the mean annual visibility at noon on weekdays,  $\sigma$  is the standard deviation, and  $S$  is the skewness. Table 4 contains the results obtained for the 1960–70 period. The mean visibility has a slight decreasing trend with no observable trend appearing in the standard deviation or skewness values. The distribution of visibility values for each of the 11 years is slightly skewed in the direction of high visibilities, as indicated by small positive values of the skewness parameter  $S$ .

Fig. 6 shows the variation of mean annual visibility from 1960–70. The data have been separated into two groups. Values for 1960–64 are grouped together as

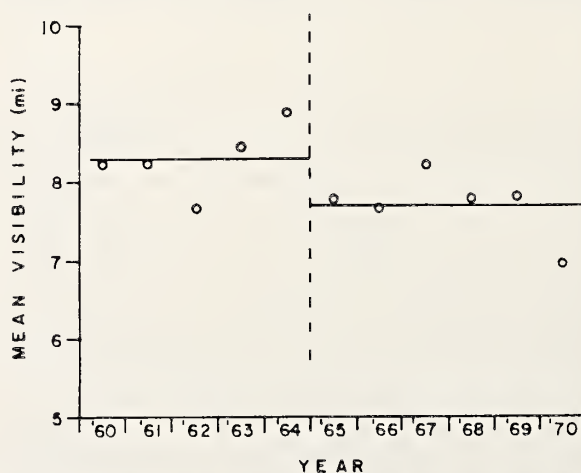


FIG. 6—Mean annual visibility at Norfolk, Virginia (1960–70).

<sup>3</sup> Lea, Duane A. (1970): A Preliminary Analysis of Visibility Trends at Point Mugu, 1949–1969. U.S. Navy Pacific Missile Range Geophysics Division Atmos. Sci. Tech. Note 22a.

<sup>4</sup> Chass, R.L. and Keith, R.W. (1971): Downtown Los Angeles Noon Visibility Trends 1933–1969. In Preprints, Conf. Air Pollution Meteorol., Raleigh, N.C., Am Meteorol. Soc., Boston.

are the values for 1965–70. This separation appears somewhat arbitrary; however, it will be more completely justified by later considerations of low visibility frequencies. The mean visibility average for 1960–64 is 13.4 km (8.3 mi), while that for 1965–70 is 12.4 km (7.7 mi). This represents a decrease of 7.2 percent.

Of the three statistical parameters considered, only the mean annual visibility gives an indication of decreasing visibility. For this reason, attention is next directed to the frequencies of visibility values in particular distance intervals. The histograms for 1960 and 1964 in Fig. 7 are typical for the years 1960–64. Similarly, the histograms for 1965 and 1969 are representative of the 1965–70 period. Since the visibilities exceeding 24.1 km (15 mi) were not recorded at the Norfolk Regional Airport due to lack of suitable objects, the high visibility data designated as 15+ is included in the 22.5- to 25.7-km (14- to 16-mi) inter-

val. The highest frequency in the data is associated with visibilities in the 9.7- to 12.9-km (6- to 8-mi) range. Visibility histograms for 1965–70 differ significantly from those for 1960–64 at low visibility frequencies. An examination of Fig. 7 reveals a pronounced shift towards lower visibilities for later years.

Fig. 8 shows the occurrence of visibilities in the 0- to 6.4-km (0- to 4-mi) range for the 11 years. The solid horizontal lines in Fig. 8 indicate the average frequencies for the periods 1960–64 and 1965–70. A distinct grouping of the data into these two intervals is noticeable; it also provides additional justification for the initial grouping in Fig. 6 of the data into the same two time periods. The average frequency for the 0- to 6.4-km (0- to 4-mi) range is 37 percent higher for years after 1965.

A shift of frequencies into low visibility intervals

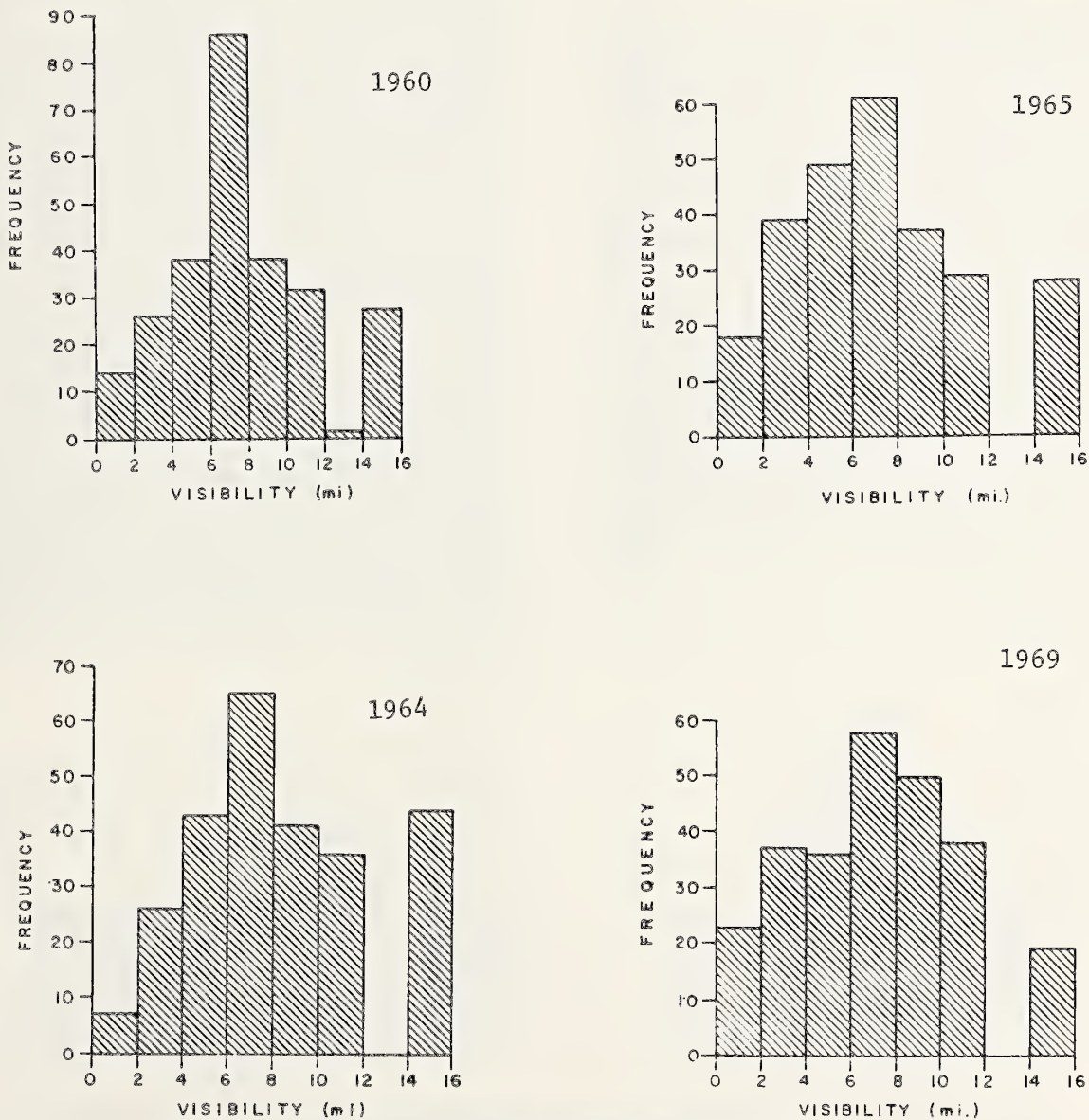


FIG. 7—Visibility histograms at Norfolk, Virginia (1960, 1964, 1965, 1969).



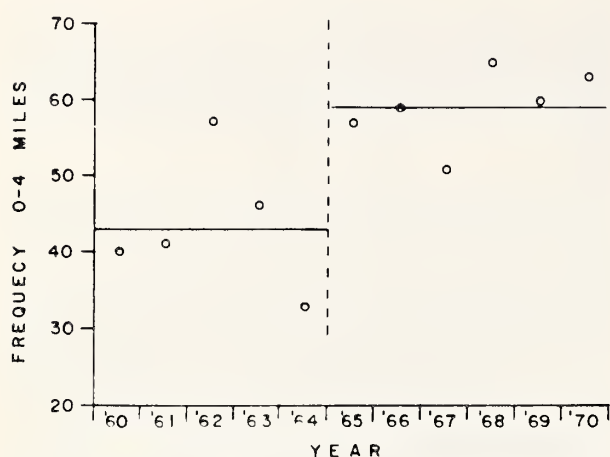


FIG. 8—Frequency of visibility in the 0- to 6.4-km (0- to 4-mi) range at Norfolk, Virginia (1960-70).

should be expected to accompany a corresponding shift away from high visibility intervals. Examination of Figs. 7 and 8 reveals this occurrence. It appears, however, that the frequencies of very high visibility intervals [e.g. those exceeding 19.3 km (12 mi)] do not change appreciably. The solid horizontal line in Fig. 9 is drawn at the average frequency for the entire 11-year interval, and the 2 dashed horizontal lines represent the averages for the 2 time intervals 1960-64 and 1965-70. This diagram does not reveal any significant trend for large visibilities.

The only measure of visibility which shows a substantial decrease is the frequency of visibilities in the 0- to 6.4-km (0- to 4-mi) range. It seems that the frequency of occurrence of low visibilities is the most sensitive measure of the effect of air pollutants on visibility. This result is in agreement with the findings of Chass and Keith (1971) based on an analysis of visibility data recorded at noon on weekdays in downtown Los Angeles for the period 1933-69. They reported a marked increase in the frequency of visibilities in the 4.8- to 9.7-km (3- to 6-mi) range, whereas the annual mean visibility showed only a slight declining trend.

These results are also confirmed by those obtained

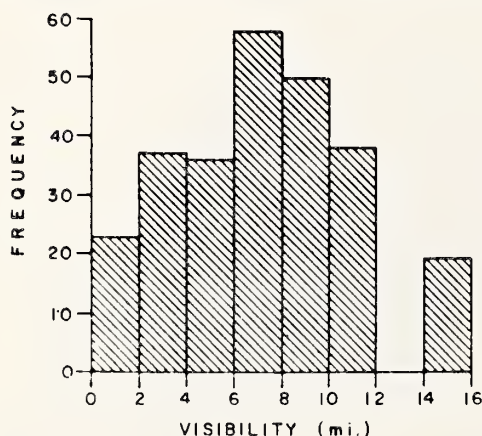


FIG. 9—Frequency of visibilities equal to or exceeding 19.3-km (12-mi) range at Norfolk, Virginia (1960-70).

by Miller et al. (1972). They analyzed the visibility data taken at airport weather stations near Akron (Ohio), Lexington (Kentucky), and Memphis (Tennessee) at 3-hour intervals from 0700 to 1900 EST for June through September during the period 1962-69. Like Pritchard and Chopra, they found it convenient for comparison purposes to divide the data into 2 4-year periods 1962-65 and 1966-69, and concluded that the frequency of visibility values in the 0- to 9.7-km (0- to 6-mi) range were substantially higher for the later period. They had excluded visibility observations when precipitation occurred or the relative humidity exceeded 70 percent. The average percentage of frequency of visibility in the 0- to 9.7-km (0- to 6-mi) range increased from 8.8 percent for 1962-65 to 20.4 percent for 1966-69. This increase can be attributed only to particulates in air.

*Correlation between Visibility and Moisture in Air*—To gain further information concerning the physical factors involved, mean visibilities were computed for each month for each of the 11 years. These monthly means were then averaged separately for the two periods. The results are plotted in the form of two visibility curves in Fig. 10. The visibility curve for the 1965-70 period differs substantially from that of the 1960-64 period. Visibility values are generally lower in the later period. The seasonal spring visibility maximum in the 1960-64 curve does not appear in the 1965-70 curve. However, a pronounced summer visibility minimum is present in the 1965-70 curve.

It appears that the visibility curve for the 1960-64 can be explained on the basis of seasonal variations in meteorological elements. Figs. 11 and 12 show the plots of monthly averages of relative humidity and precipitation at Norfolk for the 25-year period 1937-62 as found in the Weather Handbook by Conway<sup>5</sup>. These data are for relative humidity at 1300 EST and for total precipitation.

The most significant feature of the 1960-64 visibility curve in Fig. 10 is a pronounced spring maximum occurring in the month of April. This maximum is probably associated with the seasonal minimum in relative humidity. Fig. 13 displays both mean visibility for the 1960-64 period and the mean relative

<sup>5</sup> Conway, W. M., Jr., ed. (1963): Weather Handbook. Conway Publications, Atlanta, Ga.

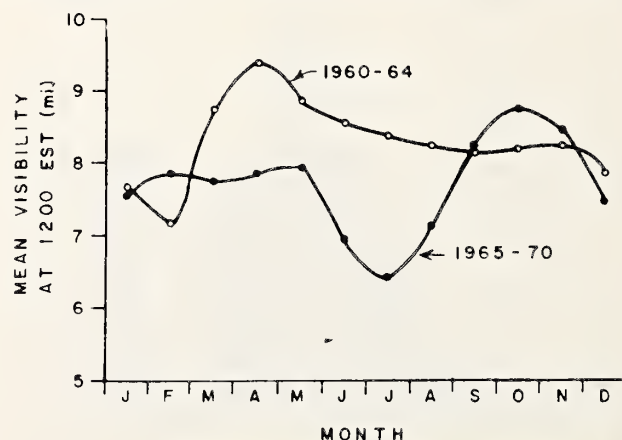


FIG. 10—Monthly mean visibilities for 1960-64 and 1965-70 at Norfolk, Virginia.

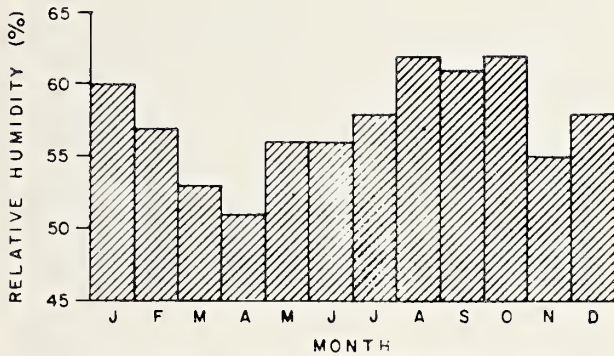


FIG. 11—Averaged monthly relative humidity at Norfolk, Virginia (1937-62).

humidity. The minimum for relative humidity in April coincides exactly in time with the spring visibility maximum. An examination of the correlation between visibility and relative humidity for coastal air given in Fig. 4 together with the relative humidity data of Fig. 11 indicates that only in the spring months should relative humidity significantly affect visibility measurements. The decline in visibility from the spring peak is probably due to a combination of rising relative humidity and the seasonal increase in precipitation during the summer months. The weak fall visibility maximum may be associated with the seasonal minimum in precipitation. The explanation for the visibility minimum in February is not clear, but it may be related to the fact that the visibility and relative humidity data do not correspond to exactly the same time intervals.

The difference between the visibility curves for the 1960-64 and 1965-70 periods may be attributed to an increase in the atmospheric concentration of particulate matter. These particles decrease visibility by scattering and absorbing light. Under certain conditions, their effectiveness in reducing visibility is increased by their ability to become larger. Hygroscopic particles may absorb water vapor from the air, and other particles may serve as condensation nuclei for water vapor. The combined effect on visibility of water vapor and airborne particles should be particularly

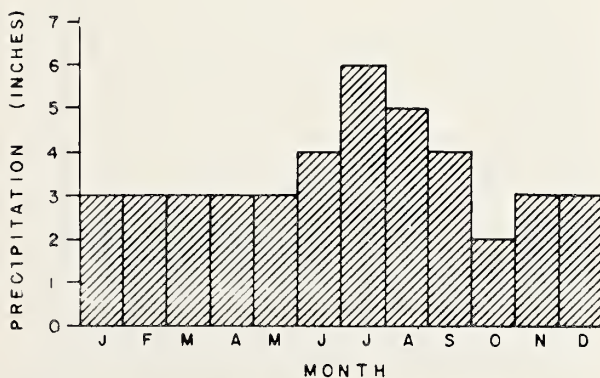


FIG. 12—Averaged monthly precipitation at Norfolk, Virginia (1937-62).

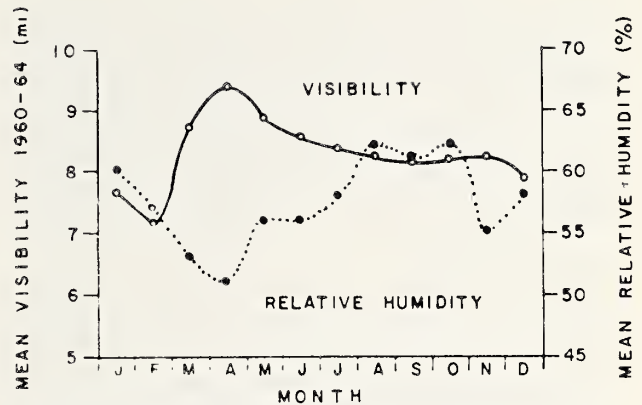


FIG. 13—Plots of mean monthly visibility (1960-64) and relative humidity at Norfolk, Virginia.

pronounced during the summer months and can account for the summer visibility minimum for the 1965-70 period. Relative humidity and temperatures are higher in the summer, thus the air moisture content can be higher than in winter even for the same relative humidity.

Fig. 14 shows the mean monthly visibilities for the 1965-70 period together with the mean monthly precipitation. An examination of Fig. 14 reveals that the summer minimum for visibility coincides exactly in time with the seasonal maximum in precipitation. Precipitation tends to wash particulate matter out of the atmosphere. However, it should be noted that precipitation at Norfolk during the summer months is most common in the late afternoon and evening while the visibility data were recorded at noon when the atmospheric moisture content is high.

The visibility curve for 1965-70 exhibits a fall maximum in October. It is apparent from Fig. 14 that this visibility maximum occurs at exactly the same time as the seasonal minimum in precipitation. The relative humidity at Norfolk (Fig. 11) also has a minimum in the fall.

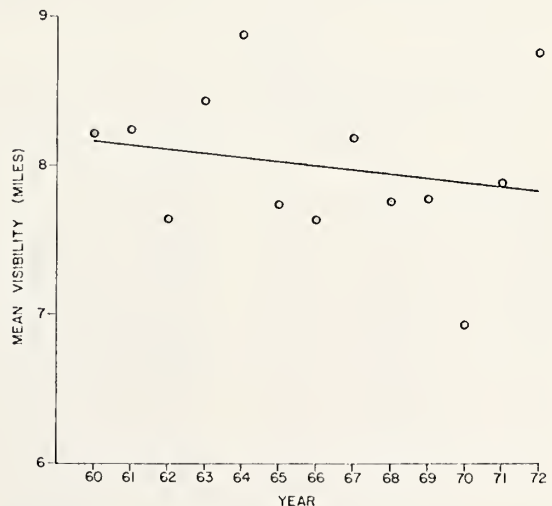


FIG. 14—Mean annual visibility at Norfolk, Virginia (1960-72).



In summary, this analysis of visibility data at Norfolk, Virginia indicates that the visibility decreased during 1960–70. The probable cause of this decrease is an increase in the concentration of particulate matter in the atmosphere. It is not possible to identify the sources or nature of the particulates for this visibility analysis. Since there are no known natural sources of additional particulates in this region, it can be concluded that the increase in particulate matter is due to man-made sources.

*Linear Regression Analysis of Visibility and Precipitation Data (1960–74)*—The mean annual visibility and frequencies of low (0–6.4 km; 0–4 mi) and high (19.2+ km; 12+ mi) visibilities are listed in Table 5. The mean annual visibilities from 1960–72 (Fig. 14) show a slight trend toward reduced visibility. The solid line is the linear regression line for mean annual visibility  $\bar{V}$  in miles given by

$$\bar{V} = 8.20 - 0.0275 N \tag{15}$$

where  $N = 1, 2, 3 \dots 13$  is the year index beginning with  $N = 1$  for 1960. The regression line indicates a slight decreasing trend over the 13-year period. A reversal of this trend may have occurred, however, possibly beginning in 1972. The mean annual visibilities for 1973 and 1974 are 14.76 km (9.17 mi) and 15.40 km (9.57 mi), respectively. These values are considerably higher than the values given by the regression line.

The annual frequencies of visibilities in the 0- to 6.4-km (0- to 4-mi) range (Fig. 15) for the period 1960–72 fit the regression line

$$F = 41.5 + 1.58 N \tag{16}$$

where  $F$  is the annual frequency. In this case, a significant increasing trend is observed. The frequency of low visibilities, as given by the regression line, increased by 44 percent between 1960–72. A possible trend reversal after 1972 is observed here also. The frequencies of visibilities in the 0- to 6.4-km (0- to 4-mi) range decreased to 48 in 1973 and to 41 in 1974.

An increase in low visibilities may be expected to

TABLE 5  
Summary of Visibility Data for Norfolk (1960–74)

Year	Mean Annual Visibility		Frequency of Visibility	
	km	(mi)	0–4 mi	12–15 mi
1960	13.21	(8.21)	40	59
1961	13.24	(8.23)	41	57
1962	12.31	(7.65)	57	54
1963	13.58	(8.44)	46	70
1964	14.27	(8.87)	33	80
1965	12.46	(7.74)	57	57
1966	12.30	(7.64)	59	52
1967	13.18	(8.19)	51	68
1968	12.49	(7.76)	65	54
1969	12.50	(7.77)	60	57
1970	11.15	(6.93)	63	32
1971	12.70	(7.89)	58	63
1972	14.11	(8.77)	53	78
1973	14.74	(9.16)	48	102
1974	15.40	(9.57)	41	104

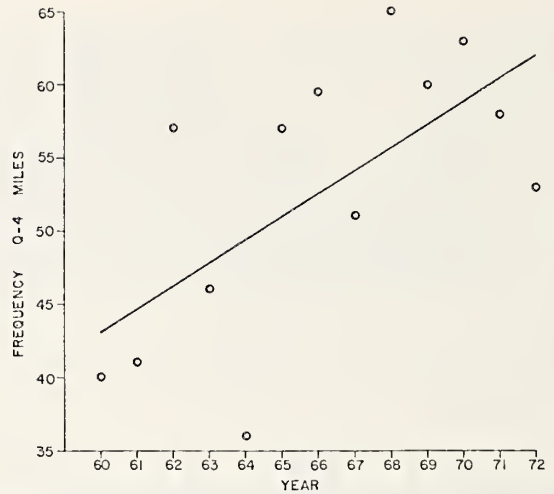


FIG. 15—Annual frequency of 0- to 6.4-km (0- to 4-mi) visibility at Norfolk, Virginia (1960–72).

accompany a concurrent decrease in high visibilities. The annual frequencies of visibilities in the 19.3+ km (12+ mi) range (Fig. 16) from 1960–72 bear this out. The regression line for these high visibilities is given by

$$F = 61.0 - 0.132 N \tag{17}$$

This equation indicates a slight decreasing trend for high visibilities. The data for 1973 and 1974 do not follow this trend. The annual frequencies of visibilities in the 19.3+ km (12+ mi) range were 102 in 1973 and 205 in 1974. Both of these frequencies are far above the regression line.

The availability of condensation nuclei from anthropogenic sources may lead to increased precipitation patterns in and around urban areas. To investigate this effect, precipitation data from the weather station at Norfolk Regional Airport was used. Data on total annual precipitation  $P$  (Fig. 17) and annual number of days  $F_p$ , with precipitation exceeding

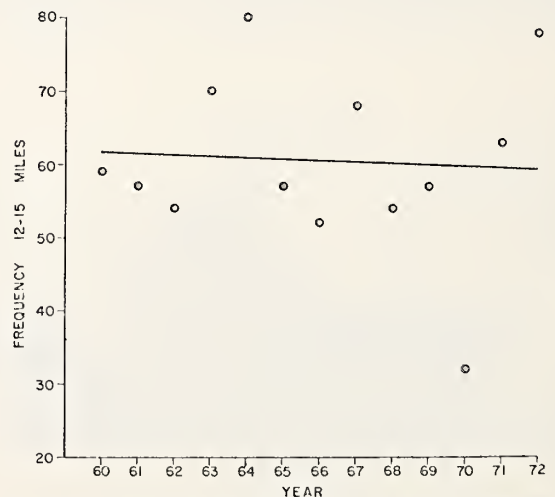


FIG. 16—Annual frequency of 19.3+ km (12+ mi) visibility at Norfolk, Virginia (1960–72).

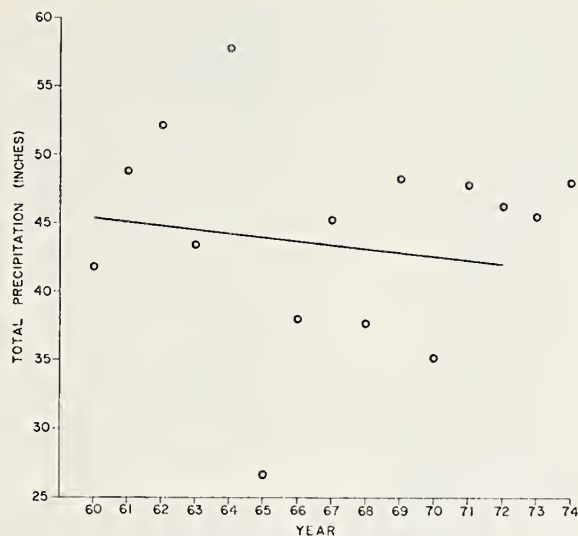


FIG. 17—Total annual precipitation at Norfolk, Virginia (1960–74).

0.254 mm (0.01 in.) (Fig. 18) were considered for the years 1960–74. The regression lines for the data through 1972 are described by

$$P(\text{in}) = 45.7 - 0.284 N \quad (18)$$

and

$$F_p(\text{days}) = 110.7 + 0.379 N \quad (19)$$

A slight decreasing trend in  $P$  and a slight increasing trend in  $F_p$  is apparent. The value of  $F_p$  computed from the regression equation increased by 4 percent between 1960–74. An examination of the rainfall data (Figs. 17 and 18) shows the trends of the regression lines based on data for the period 1960–72 should continue through 1973–74.

**Conclusions and Discussion of Visibility Trends at Norfolk**—Significant decreases in visibility at Norfolk occurred during the 13-year period 1960–72. This decrease may be related to an increasing atmospheric concentration of particulates. The most pro-

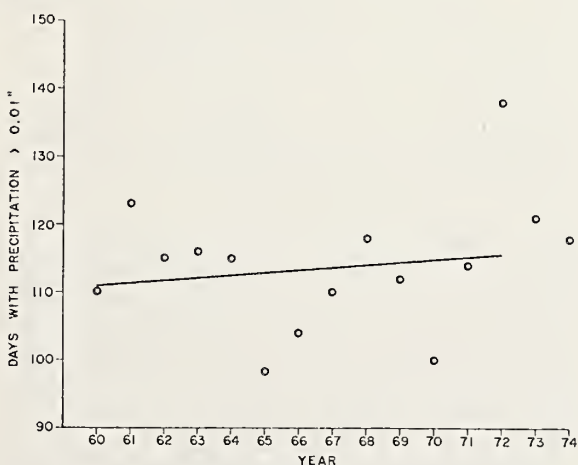


FIG. 18—Annual frequency of days with precipitation exceeding 0.254 mm (0.01 in.) at Norfolk, Virginia (1960–74).

nounced effect was a substantial increase in the annual frequency of low (0- to 6.4-km; 0- to 4-mi) visibilities. The declining visibility at Norfolk was associated primarily with sharply lower visibilities during the summer months. This is due to the combined effects of increasing air pollution and a seasonal high in relative humidity. Hygroscopic particles in air absorb water and grow in size when the relative humidity is high. Larger particles are more effective in reducing visibility.

The extremely high visibilities observed at Norfolk during 1973 and 1974 are more difficult to account for. Some reduction in the generation of particulates appears to have occurred. The Virginia Air Pollution Control Board began in 1972 to enforce regulations designed to reduce air pollution from point sources. The principal point sources of particulates in the Norfolk area are incinerators and businesses engaged in construction and production of asphalt and fertilizers (Table 6). Since 1972, emissions of particulates from these sources have substantially decreased. However, the extent of the reduction in particulate emissions from heating systems and automobile engines is uncertain.

Precipitation data for the entire 1960–74 period show a slightly increasing trend in the annual frequency of days with precipitation greater than 0.254 mm (0.01 in.). This effect may also be due to particulates in air. In addition, some correlation between visibility and precipitation data is expected. A cross-correlation plot of the annual frequency of days with precipitation exceeding 0.254 mm (0.01 in.) versus the annual frequency of visibility in the 0- to 6.4-km (0- to 4-mi) range is shown in Fig. 19. The correlation coefficient, for the entire 1960–74 period is

$$R = \frac{\sum_{i=1}^{15} (F_{vi} - \bar{F}_v)(F_{pi} - \bar{F}_p)}{\left[ \sum_{i=1}^{15} (F_{vi} - \bar{F}_v)^2 \sum_{i=1}^{15} (F_{pi} - \bar{F}_p)^2 \right]^{1/2}} \quad (20)$$

$$= -0.296$$

Here  $F_{vi}$  and  $F_{pi}$  are the annual frequencies for visibility and precipitation, respectively, and  $\bar{F}_v$  and  $\bar{F}_p$

TABLE 6  
Principle Point Sources of Particulates in Norfolk-Portsmouth Area (1972)

Source	kg/day	Emission (tons/day)
Norfolk Naval Air Station	1524.07	(1.68)
City of Norfolk Incinerator	1353.06	(1.49)
Ames and Webb, Inc.	4540.46	(5.00)
Contractors Paving Co.	2079.53	(2.29)
Asphalt Roads & Materials, Inc.	4404.25	(4.85)
Portsmouth Paving Co.	6147.78	(6.77)
Norfolk Vencer Mills	1107.87	(1.22)
Finley Paving Co.	9062.76	(9.98)
Swift Agricultural Chemicals	1316.73	(1.45)
Smith-Douglass	1225.92	(1.35)
City of Portsmouth Incinerator	871.77	(0.96)
Total Particulate Emission	33,634.20	37.04





FIG. 19—Correlation between visibility and precipitation at Norfolk, Virginia (1960-74).

are the 15-year averages of the  $F_{vi}$  and  $F_{pt}$  values. The correlation coefficient  $R$ , though small, is negative and is consistent with the hypothesis that the effect of precipitation is to increase visibility by washing the particulate matter out of the atmosphere.

### Shopping Centers as Heated Islands

Two neighboring shopping centers at Norfolk were selected for heat island studies. These are the Wards Corner and Southern Shopping Center areas. Fig. 20 is the street map of the region surrounding the shopping centers in 1971-72.

The choice of Wards Corner was based on a number of factors. This shopping center is compact and fairly symmetrical, with a sharp contrast between commercial and residential areas. It was anticipated that the symmetry would facilitate the development of a mathematical heat island model, and that the sharp difference would produce a large contrast in temperature.

Preliminary measurements indicated the existence, under certain conditions, of a significant temperature difference between the center of the commercial area and the surrounding residential sections. In addition, a major traffic intersection is located at the center of the shopping center. The resulting concentration of automotive heat sources might be expected to enhance the heat island effect.

Southern Shopping Center is close to Wards Corner and temperature measurements could conveniently be made for both areas on a single field trip. This shopping center, in contrast to Wards Corner, is very asymmetrical. Whereas the commercial buildings at Wards Corner are all fairly close together, the buildings at Southern Shopping Center are for the most part concentrated into two groups located on opposite sides of a major street and further separated by extensive parking areas. Consequently, the heat island structure is more complex, and the overall temperature contrast should be smaller. As a result of an underpass, there is no major traffic intersection associated with Southern Shopping Center, and the influence of automotive traffic on the heat island effect is less compared with Wards Corner.

*Equipment and Data Collection*—Automobile tra-

verses were selected as the best technique for obtaining an adequate amount of air temperature data over a reasonably short period of time. Temperature measurements were made by means of electrical resistance thermometers of the thermistor type with the temperature probes rigidly mounted on automobiles at a height of two meters above the pavement. The battery-operated, direct-reading, temperature-recording units utilized electrical bridge circuitry and were calibrated so that deflection readings on a microammeter were proportional to temperature. The temperature sensing thermistors were equipped with radiation shields which allowed natural ventilation. Daytime temperature measurements were made in sunlight whenever possible. Due to the rapid response time of the instruments, it was usually necessary to stop at a data collection point for no more than 30 seconds.

Temperature data were recorded during a number of field trips during the spring and summer of 1971 and the summer of 1972. In addition, measurements of wind speed and direction were made on the 1972 field trips. The wind data were obtained by means of an anemometer attached to an automobile. The anemometer vane and the temperature probe were at the same height, two meters above the pavement. To determine true wind directions, it was necessary to take a compass reading to establish the orientation of the car at the time each measurement of wind direction was made.

Measurements were made at a fixed set of 73 points selected to allow the mapping of heat islands in terms of isothermal lines. Most of the field trips were conducted in the afternoon between 1400 and 1600 EST. The total time required to collect a set of data was about one hour. In general, no significant temperature changes at particular points over the data collection period were observed. This effect was investigated in two ways. Measurements made at certain points at the beginning were repeated at the end of the data collection period. Two research teams in separate cars collected data at Wards Corner and Southern Shopping Center, respectively. Some assigned data collection points were common to both teams, and thus measurements made at these test points at different times could be compared. A few field trips were made at night to investigate the difference in the day and night heat island effects.

*Typical Temperature Patterns in and around Shopping Centers*—A visual description of a shopping center heat island can be obtained by plotting isothermal lines. Temperature data recorded at a fixed set of points during afternoon field trips to the Wards Corner and Southern Shopping Center areas were used to prepare isotherm maps of the two heat islands. Fig. 21 shows the isotherm pattern for Wards Corner on April 16, 1971. Fig. 22 displays the pattern obtained by averaging temperature data taken on three days in June 1972 under approximately the same meteorological conditions. Fig. 23 is an isotherm mapping of the combined Wards Corner and Southern Shopping Center heat islands for May 6, 1971.

In general, the afternoon isothermal heat island patterns for the two shopping centers appear to be independent of time. Thus, Figs. 21-23 can be consid-

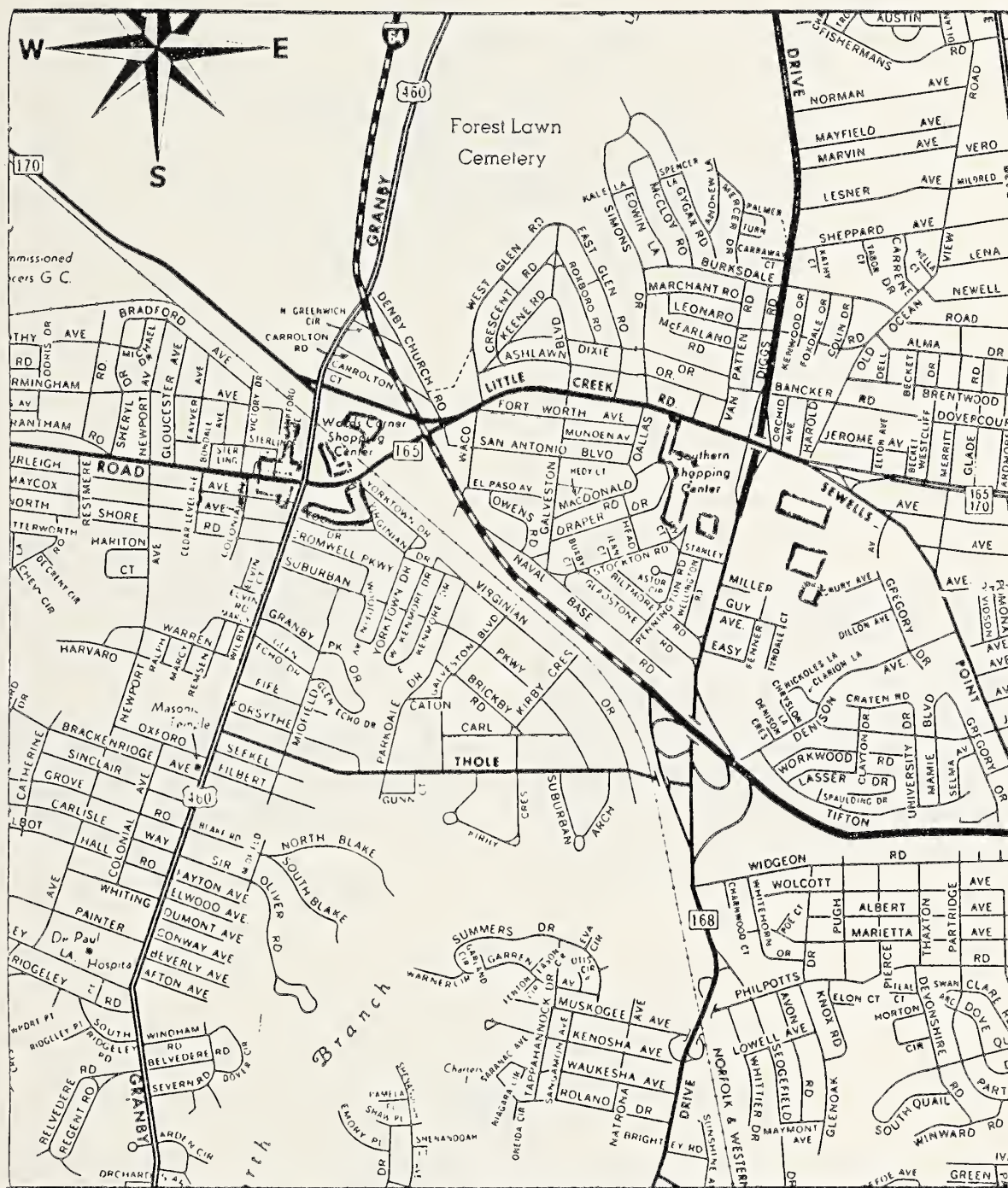


FIG. 20—Street map of Wards Corner and Southern Shopping Center at Norfolk, Virginia (1971-72).

ered to be representative isotherm charts for the afternoon heat island effect. The observed maximum temperature difference  $\Delta T_m$ , called the heat island magnitude, is variable even though the isotherm pattern remains the same. Values of  $\Delta T_m$  ranged from 4 to 7°F with the largest value being observed for Wards Corner on April 16, 1971. The heat island magnitude was generally higher at Wards Corner than at Southern Shopping Center due to the sharper transition from commercial to residential areas at Wards Corner.

The isotherm patterns for Wards Corner (Figs. 21 and 22) are generally symmetrical as expected from geometric considerations. Patterns for Southern Shopping Center are highly asymmetrical with the heat island exhibiting a double temperature maximum due to the two major concentrations of buildings.

The effect of overlapping shopping center heat islands is apparent in Fig. 23. The temperature along a line joining the two shopping centers never decreases to the minimum residential area temperature.





FIG. 21—Wards Corner shopping center as a heated island (April 16, 1971).

The isothermal heat island patterns displayed in Figs. 21–23 are all based on temperature data recorded on calm, clear afternoons.

*Numerical Heat Island Models for Shopping Centers*—An alternative to the graphical description of heat islands (Figs. 21–23) is the development, by means of Fourier analysis, of an empirical equation to describe the horizontal temperature distribution. This procedure has been previously employed by Preston-Whyte (1970) to describe the temperature pattern at Durban, South Africa.

The general form of the empirical equation for the spatial temperature distribution is

$$T = \bar{T} + \sum_{n=1}^n C_n \sin\left(\frac{\pi nx}{L} + \phi_n\right) \quad (21)$$

where  $\bar{T}$  is the mean temperature,  $C_n$  is the amplitude of the  $n$ -th harmonic,  $x$  is the distance in miles from the origin,  $L$  is a characteristic length, and  $\phi_n$  is the phase angle associated with the  $n$ -th harmonic. The coefficients  $C_n$  can be obtained by Fourier analysis of

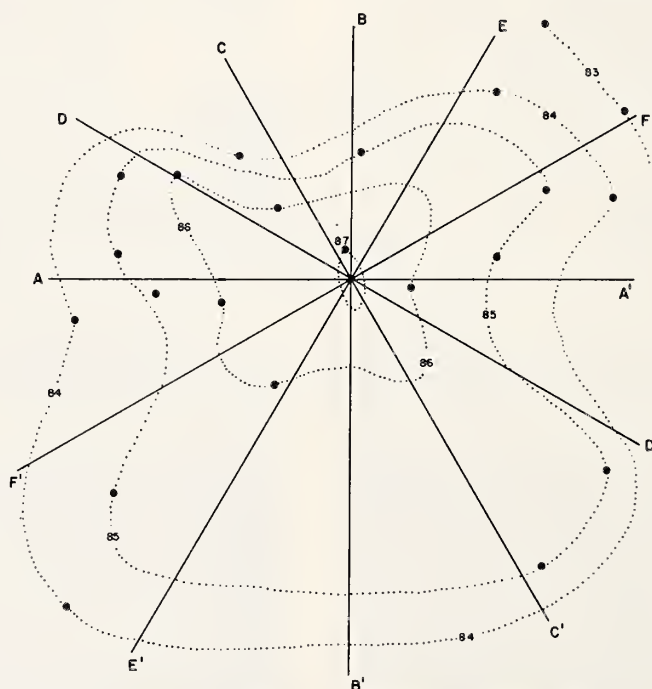


FIG. 22—Temperature pattern in and around the Wards Corner shopping center (average for June 13, 15 and 16, 1972).



FIG. 23—Isotherm map for the Wards Corner and Southern Shopping Center area (May 6, 1971).

the temperature data. The standard Fourier cosine coefficients  $A_n$  and sine coefficients  $B_n$  are given by

$$A_n = \frac{1}{L} \int_{-L}^L T(x) \cos\left(\frac{\pi n x}{L}\right) dx \quad (22)$$

and

$$B_n = \frac{1}{L} \int_{-L}^L T(x) \sin\left(\frac{\pi n x}{L}\right) dx \quad (23)$$

Also,

$$A_n = \bar{T} + \frac{1}{2L} \int_{-L}^L T(x) dx \quad (24)$$

It can easily be shown that the coefficients  $C_n$  are

related to  $A_n$  and  $B_n$  by

$$C_n = (A_n^2 + B_n^2)^{1/2} \quad (25)$$

and that the phase angles  $\phi_n$  are given by

$$\phi_n = \tan^{-1}(B_n/A_n) \quad (26)$$

The Fourier analysis is complicated by the fact that numerical integrations are required to evaluate the  $A_n$  and  $B_n$  from equations (22) and (23). Since the number of temperature data points is comparatively small, direct numerical integrations using measured temperatures are inaccurate. This difficulty can be avoided by drawing traverse lines on the isotherm maps. A separate empirical temperature equation can be obtained for each traverse line by using the inter-

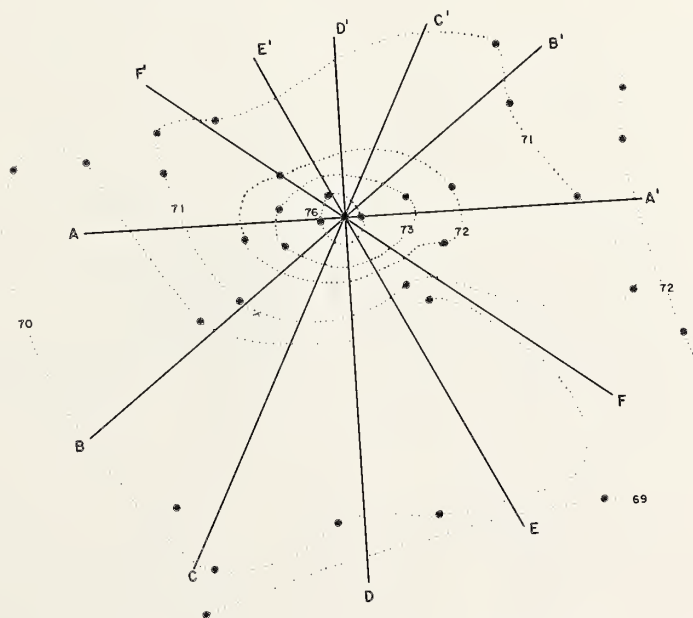


FIG. 24—Temperature pattern (April 16, 1971) for Wards Corner with superposed traverse lines.



TABLE 7  
Numerical Model Parameters for Wards Corner Heat Island Effect  
(April 16, 1971)

Traverse	$\bar{T}$ (°F)	$C_1$	$\phi_1$	$C_2$	$\phi_2$	$C_3$	$\phi_3$
AA'	73.4	2.48	89°	0.377	257°	0.151	84°
BB'	73.0	2.43	87	0.578	255	0.356	101
CC'	72.7	2.46	86	0.813	260	0.470	84
DD'	72.7	2.61	84	0.944	261	0.390	70
EE'	72.7	2.64	83	0.879	260	0.396	68
FF'	72.7	2.70	80	0.644	266	0.226	54
Average	72.9	2.55	85°	0.706	260°	0.332	77°

sections of isotherms with the traverse line in conjunction with linear interpolation to generate temperatures at 25 equally spaced points.

A computer program was developed for the calculation of  $T$ ,  $C_n$ , and  $\phi_n$  for  $n$  up to 5 from the 25 temperature values for a traverse line. This program was used with the Old Dominion University IBM 1130 computers to generate numerical temperature models. The origin of the coordinate system for each model is the intersection of the traverse lines.

Figure 24 shows traverse lines drawn on the isotherm map of Wards Corner for April 16, 1971. Table 7 gives the results of the Fourier analysis of this temperature distribution. An examination of Table 7 indicates that the empirical temperature equations for the 6 traverse lines are essentially the same. Consequently, the values of  $T$ ,  $C_n$ , and  $\phi_n$  have been averaged. These average values are displayed in the last row of figures in Table 7. It appears that the heat island effect in this case is well described by a single equation of the form of equation (21) with  $L = 0.97$  km (0.6 m). This equation is

$$T = 72.9 + 2.25 \sin (300x + 85) + 0.71 \sin (600x + 100) + 0.33 \sin (900x + 77) \tag{27}$$

Similarly, the temperature pattern for Wards Corner (Fig. 22) obtained by averaging the data for three days in June 1972 can be analyzed by drawing traverse lines as shown in Fig. 25. The results of the Fourier analysis for this case are given in Table 8. Average values of  $T$ ,  $C_n$ , and  $\phi_n$  are again listed in the last row of this table.

Three separate Fourier analyses were carried out for the isotherm map of the combined two shopping center areas (Fig. 23): one for Wards Corner alone, one for Southern Shopping Center alone, and one for the entire area. Fig. 26 shows the traverse lines employed for these three calculations. In all three cases, the horizontal line is designated AA' and  $x$  values to the left of the origin are negative. Traverse BB' is rotated 30° counterclockwise relative to AA'. Traverse CC' is rotated 30° counterclockwise relative to BB', etc. The results of the Fourier analyses are presented in Tables 9, 10, and 11. Average values of  $T$ ,  $C_n$ , and  $\phi_n$  are given only for the Wards Corner analysis (Table 9) since the results for the combined area and for Southern Shopping Center alone (Tables 10 and 11) indicate that these temperature distributions are quite asymmetric and therefore averaging is not appropriate.

It is apparent from an examination of Tables 7 to 12 that only in the case of the Wards Corner heat island is it possible to describe the horizontal temperature distribution by a single equation. In the other cases, separate empirical equations are required for each traverse line. The averaged temperature parameters for Wards Corner given in Tables 8 and 9 are quite similar. The large values of the averaged  $C_n$  of

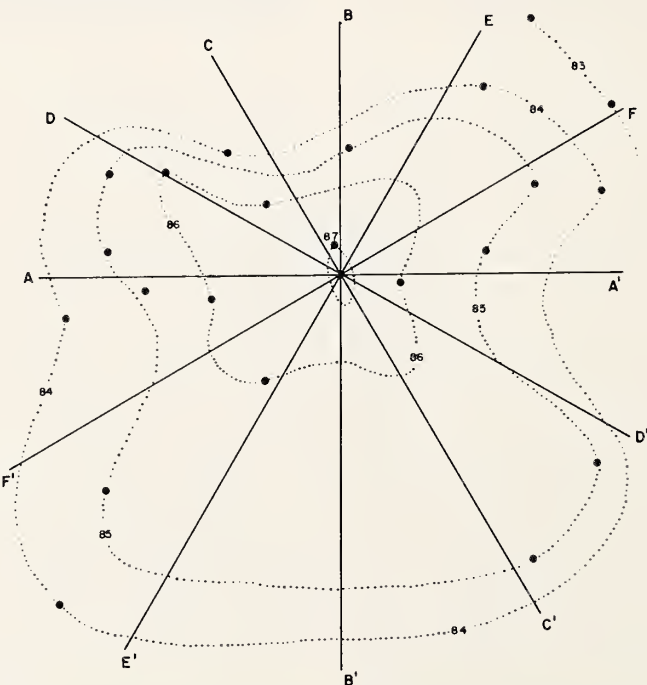


FIG. 25—Temperature pattern (averaged for June 13, 15 and 16, 1972) with superposed traverse lines.

TABLE 8  
Numerical Model Parameters for Wards Corner Heat Island (Average for June 13, 15, 16, 1972)

Traverse	$\bar{T}$	$C_1$	$\phi_1$	$C_2$	$\phi_2$	$C_3$	$\phi_3$	$C_4$	$\phi_4$	$C_5$	$\phi_5$
AA'	85.0°	1.470	94°	0.433	273°	0.0906	75°	0.0686	275°	0.0618	144°
BB'	85.1	1.372	124	0.423	266	0.365	78	0.0812	185	0.0315	29
CC'	85.2	1.394	127	0.430	264	0.322	84	0.126	176	0.0073	329
DD'	85.3	1.501	86	0.173	247	0.0929	93	0.179	271	0.0465	80
EE'	85.3	1.342	95	0.408	267	0.0965	90	0.0476	89	0.137	100
FF'	85.4	1.500	94	0.151	299	0.0824	149	0.0524	249	0.0564	24
Average	85.2	1.423	103	0.336	269	0.175	95	0.0925	208	0.0568	118

Table 7 are due to the larger value of  $\Delta T_m$  (7°F) as compared to that for the other two cases (4°F).

A single approximate temperature distribution equation for the Wards Corner heat island can be obtained by introducing the heat island magnitude  $\Delta T_m$  as a parameter. Coefficients  $C_n'$  defined by

$$C_n' = 4C_n/\Delta T_m \quad (28)$$

can be used to transform Eq. (19) to

$$T = \bar{T} + (\Delta T_m/4) \sum_{n=1}^N C_n' \sin\left(\frac{\pi n x}{L} + \phi_n\right) \quad (29)$$

Table 12 lists values of  $C_n'$  computed with the aid of Eq. (26) from  $C_n$  values given in Tables 7–9. Corresponding values of  $\phi_n$  are included in Table 12 and only the first three harmonics are considered. An examination of Table 12 reveals that the Wards Corner heat island data can be adequately described by the single temperature equation

$$T = \bar{T} + (\Delta T_m/4) [1.44 \sin(300x + 87) + 0.53 \sin(600x + 273) + 0.26 \sin(900x + 92)] \quad (30)$$

*Discussion of Shopping Center Heat Island Effect—*  
Air temperature measurements at a height of two

meters in the vicinity of two urban shopping centers located in Norfolk, Virginia indicate that under appropriate conditions shopping centers may produce microscale domes of heated air above them. A number of factors are responsible for this effect. Among these are the concentration of energy conversion devices and people in shopping centers. The energy released by the burning of fossil fuels and electrical energy expended eventually appear as heat. All human activities contribute to the thermal input to a certain extent. Probably the most important factor, however, is the physical structure of the shopping center. Brick and concrete buildings are crowded together between concrete and asphalt pavements with an almost total absence of vegetation or surface soil. This presents a marked contrast with surrounding residential areas with relatively widely spaced houses of largely wood construction, prevalent trees, and lawn areas. Concrete and similar building materials have high density ( $\sim 2.275 \text{ kg/m}^3$  or  $\sim 142 \text{ lb/ft}^3$ ) and comparatively high specific heat (0.22 Btu/lb°F). Consequently, the buildings and pavements of a shopping center can store much of the incident solar energy during the day and then release this energy at night.

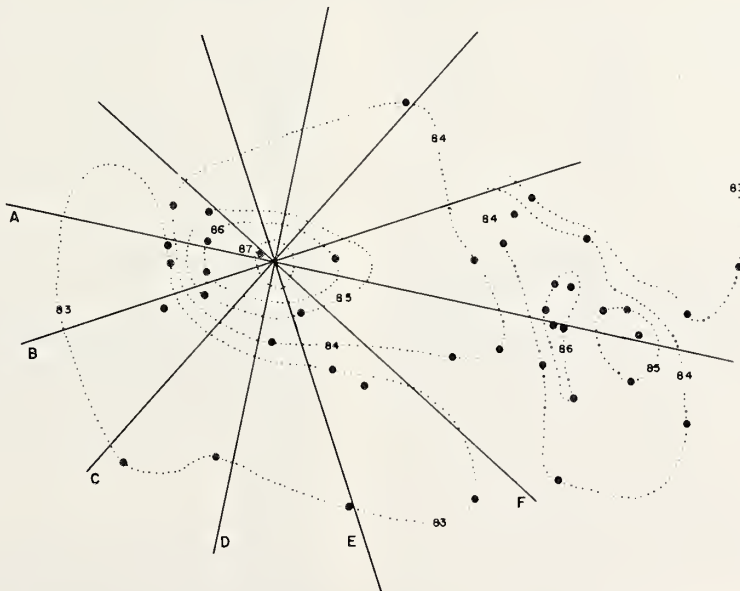


FIG. 26—Isotherm map for the Wards Corner and Southern Shopping Center (May 6, 1972) with superposed traverse lines.



TABLE 9  
*Numerical Model for Wards Corner Heat Island May 6, 1971*

Traverse	$\bar{T}$	$C_1$	$\phi_1$	$C_2$	$\phi_2$	$C_3$	$\phi_3$	$C_4$	$\phi_4$	$C_5$	$\phi_5$
AA'	84.4°	1.665	70°	0.857	290°	0.359	121°	0.225	7°	0.143	323°
BB'	84.3	1.458	70	0.850	288	0.390	105	0.229	343	0.0826	36
CC'	84.2	1.395	65	0.821	278	0.496	105	0.378	328	0.121	122
DD'	84.2	1.284	76	0.804	299	0.377	97	0.240	306	0.207	94
EE'	84.1	1.279	71	0.921	292	0.559	106	0.319	319	0.102	95
FF'	84.4	1.470	80	0.870	298	0.364	86	0.139	293	0.955	60
Average	84.3	1.425	72	0.854	291	0.424	103	0.255	326	0.125	122

TABLE 10  
*Numerical Model for Wards Corner and Southern Shopping Center Combined Heat Island (May 6, 1971)*

Traverse	$\bar{T}$	$C_1$	$\phi_1$	$C_2$	$\phi_2$	$C_3$	$\phi_3$	$C_4$	$\phi_4$	$C_5$	$\phi_5$
AA	84.8°	0.866	118	0.0152	30°	0.177	301°	0.157	219°	0.0644	251°
BB'	83.5	0.633	52	0.026	186	0.205	337	0.0270	99	0.117	262
CC'	83.3	0.549	37	0.267	164	0.003	85	0.127	238	0.0925	6
DD'	83.5	0.634	4	0.006	43	0.206	11	0.011	38	0.118	19
EE'	83.0	0.002	276	0.001	276	0.0007	281	0.0005	285	0.0004	290
FF'	83.0	0.002	276	0.001	276	0.0007	281	0.0005	285	0.0004	290

TABLE 11  
*Numerical Model for Southern Shopping Center Heat Island May 6, 1971*

Traverse	$\bar{T}$	$C_1$	$\phi_1$	$C_2$	$\phi_2$	$C_3$	$\phi_3$	$C_4$	$\phi_4$	$C_5$	$\phi_5$
AA'	84.3°	0.497	131°	0.393	295°	0.250	256°	0.122	110°	0.108	36°
BB'	83.8	0.998	160	0.383	346	0.440	203	0.110	106	0.015	154
CC'	83.8	1.116	162	0.415	368	0.381	222	0.124	175	0.157	132
DD'	83.7	0.416	163	0.280	343	0.359	192	0.055	2	0.167	188
EE'	83.8	0.923	155	0.299	317	0.297	176	0.062	257	0.092	167
FF'	84.5	0.761	76	0.435	236	0.158	4	0.151	109	0.124	276

TABLE 12  
*Heat Island Parameters for Wards Corner*

Date	$\Delta T_m$	$C'_2$	$\phi_1$	$C'_2$	$\phi_2$	$C'_3$	$\phi_3$
April 16, 1971	7°	1.457	85°	0.4034	260°	0.1897	77°
May 6, 1971	4	1.425	72	0.8539	291	0.4244	103
June 13, 14, 15, 16, 1972	4	1.432	103	0.3363	269	0.1749	95
Averages		1.438	87	0.5312	273	0.2630	92

The observed maximum spatial temperature variation associated with the shopping center heat island effect was  $\Delta T_m = 7F^\circ$ . This occurred on a relatively calm and clear day, and these conditions seem to give the most pronounced heat island effect. Although only data pertaining to the optimum conditions have been presented (Figs. 21-23), measurements were made under a variety of conditions to investigate the influence of a number of factors on the heat island effect. Such factors as sea breezes, gustiness, cloud cover, traffic, day-night differences, and differences in local surface features affect the heat island structure and change the shapes and locations of the isothermal lines.

Sea breezes are quite common in the Norfolk area.

They tend to reduce the overall  $\Delta T_m$  and as a result of channeling the flow of air by streets may produce low temperatures closer to the center of the shopping center than would normally be expected.

Significant gustiness also acts to reduce  $\Delta T_m$  and in addition causes erratic temperatures. A completely overcast condition results in a low  $\Delta T_m$ , but the symmetry of the temperature pattern is unaffected. Partial cloudiness has an effect only if the sun is covered.

Measurements at Wards Corner during peak traffic periods indicate that the additional heating due to congested traffic at the center of the shopping center increases  $\Delta T_m$  only very slightly.

As expected, temperature measurements at certain



FIG. 27—Vertical air circulation pattern (in the absence of winds) caused by an urban shopping center.

data collection points gave consistently higher or lower readings than nearby points. These results can be explained in terms of anomalies in local surface features. Hot spots were associated with large amounts of building materials and pavements as compared with adjacent points, or where there was a pocket of stagnant air. Cold spots resulted from an unusually high concentration of trees and vegetation, or certain terrain features permitting channeling of air flow.

Only a very limited amount of data was taken at night between 2200 and 2300 EDT during the summer of 1971. These data appear to indicate that the nighttime heat island effect is less pronounced. This is apparently due to the sea breeze washing or diluting the temperature contrast.

Shopping center heat islands can be represented pictorially by plotting isothermal lines. A more precise mathematical model can be obtained by the use of Fourier analysis to develop empirical equations which describe the temperature pattern with any desired degree of accuracy. An asymmetrical pattern requires a different equation for each traverse line selected and hence the mathematical model is complex. It was found, however, that a generally symmetrical heat island can be adequately described by a single empirical equation containing only three harmonic terms and including the mean temperature  $\bar{T}$  as a parameter. Furthermore, this equation could be extended to a two-parameter equation involving both  $\bar{T}$  and the heat island magnitude  $\Delta T_m$ . This general equation can be used to generate a mathematical model of the heat island on the basis of a relatively small number of temperature measurements. It might be noted in connection with Eq. (28) that the empirical heat island equation developed by Preston-Whyte (1970) by Fourier analysis of temperature data contains only one parameter,  $\bar{T}$ . It is clear, however, that a general temperature equation must include  $\Delta T_m$  as well as  $\bar{T}$ .

Since the transition from the shopping center core to the residential areas takes place over a small horizontal distance, temperature gradients associated

with shopping center heat islands may be large. This is particularly so in the case of the Wards Corner shopping center. These high temperature gradients along the horizontal are very effective in generating local wind circulation patterns which may affect the microclimate of the area. There is an upwelling of warm air near the center of the heat island. This warm air rises toward the top of the dome of heated air and cools as it rises. It then moves outward from the center and downward towards the edge of the dome. Finally, the horizontal pressure gradient causes a return flow of air near the surface inward toward the center of the shopping center. Thus, a solenoidal convective air circulation loop is established. The vertical section of the convective loop is shown in Fig. 27. The air circulation pattern induced by two neighboring shopping centers is more complex. Fig. 28 illustrates the pattern of air currents in a vertical section through a line joining the Wards Corner and Southern Shopping Centers. Simultaneous measurements of humidity and temperature are needed to determine the extent of vertical ascent of air above the shopping areas.

Information gained by heat island studies may have significant applications in connection with efforts to achieve better design and planning of our cities. Two important factors are the generation of local winds or breezes and the influence these have on the systematic transport of air pollutants to the surrounding residential areas. It is apparent from the results of the present study that heat island effects on a smaller horizontal distance scale than those previously considered merit further investigation.

### Concluding Remarks

The atmosphere at Norfolk is stable with winds having no preferential direction. Norfolk, being a coastal city, is subjected to the influence of land and sea breezes and other winds which provide recycling of air rather than flushing pollutants out of the Norfolk air via ventilation. The atmospheric stability inhibits vertical mixing and dispersal of air pollutants. Therefore, the quality of air at Norfolk is determined principally by local sources of air pollution. Contrary to the frequently public but often contradictory claims by the State Air Pollution Control Board, the quality of air at Norfolk is not significantly influenced by transport of air pollutants by winds from distant metropolitan centers or other sources from the north or south.

Trends in noontime visibility measurements appear to be reliable indicators of particulate concentration in the Norfolk air. The local Air Pollution Control Board should be commended for enforcing particu-



FIG. 28—Vertical air circulation patterns (in the absence of winds) caused by two neighboring shopping centers.



late levels; these levels appear to show a decreasing trend.

Symmetrical and well-defined shopping centers considerably modify the local temperature environment and possibly influence other weather elements. Their location and nature should be included in considerations of future urban design in the Tidewater region.

The list of references is not exhaustive. Additional references regarding urban heat islands can be found in Chopra (1973) and Garstang et al. (1975).

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### Literature Cited

- Chopra, Kuldip P. (1971): Island-Induced Atmospheric and Oceanic Circulations. *Bull. Am. Phys. Soc.* (2) 16, 487-488.
- Chopra, Kuldip P. (1973): Atmospheric and Oceanic Flow Problems Introduced by Islands. *Adv. Geophys.* 16, 297-421.
- Chopra, Kuldip P. and Pritchard, W. Maurice (1971): Norfolk as an Urban Heat Island. *Va. J. Sci.* 22, 117.
- (1972): Heat Island Studies of Urban Shopping Centers. *Va. J. Sci.* 23, 131.
- Garstang, M., Tyson, P.D., and Emmitt, G.D. (1975): The Structure of Heat Islands. *Rev. Geophys. Space Phys.* 13, 139-165.
- Green, Charlotte R. and Battan, Louis J. (1967): A Study of Visibility vs. Population Growth in Arizona. *J. Ariz. Acad. Sci.* 9, 226-228.
- Holzworth, G.C. and Maga, J.A. (1960): Effect of Wind Speed on Visibility at Bakersfield, Calif. *J. Air Pollution Control Assoc.* 10, 430.
- Miller, Marvin E., Canfield, Norman L., Ritter, Terry A., and Weaver, C. Richard (1972): Visibility Changes in Ohio, Kentucky and Tennessee from 1962-1969. *Mon. Weather Rev.* 100, 67-71.
- Neiburger, M. and Wurtele, M.G. (1949): Correlation between Visibility and Relative Humidity at Los Angeles International Airport. *Chem. Rev.* 44, 321.
- Preston-Whyte, R.A. (1970): A Spatial Model of an Urban Heat Island. *J. Appl. Met.* 9, 571-573.
- Pritchard, W. Maurice and Chopra, Kuldip P. (1972): Effects of Air Pollution on Visibility at Norfolk. *Va. J. Sci.* 23, 157.
- (1974): Quality of Air and Visibility at Norfolk. *Va. J. Sci.* 25, 121.
- (1975): Effects of Air Pollutants on Meteorological Parameters at Norfolk. *Va. J. Sci.* 21, 82.

# Soil Lead and Zinc at an Interstate Highway Rest Stop

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**Abstract**—The Ruston-Beltsville Gravelly Fine Sandy Loam soil along interstate I-95, at the Dale City rest stop 32.2 km (20 mi) south of Washington, D.C., was analyzed for lead and zinc content presumably accumulated from automobile emissions. Analyses were conducted as a class project by college chemistry students of Northern Virginia Community College at the Woodbridge Campus. Seven transects of the rest stop area were defined with five sampling sites along each transect. Hydrochloric acid extraction was followed by analyses using a Perkin Elmer 360 Atomic Absorption Spectrophotometer. Lead contents ranged from 9 ppm to 652 ppm, and zinc from 3 ppm to 204 ppm in soils. In road bedding, materials ranges were from 222 ppm to 578 ppm for lead and 2 ppm to 6 ppm for zinc. Estimations of the magnitudes of on-loading, off-loading, and site carrying capacity were made through comparisons of values reported for other soils.

## Introduction

The proposed construction of a \$20,000,000 interchange complex for Interstate Highway I-95 at Dale City, Virginia calls in part for an expansion of rest stop facilities adjacent to the western edge of the NVCC campus at Woodbridge, Virginia. Present rest

stop facilities lie on Ruston-Beltsville Gravelly Fine Sand Loam soil which is not used for agricultural purposes and could, therefore, safely tolerate considerable loadings of heavy metals. Thus the soil could serve the expanded rest stop as a valuable sink, immobilizing these heavy metals and attenuating their off-site migration. However, the actual ability of this soil to absorb and retain lead and zinc from high volume traffic has not yet been documented in the literature.

An attempt to assess the value of the Ruston-Beltsville soil with respect to heavy metal entrainment was undertaken by third-quarter College Chemistry students at the Woodbridge Campus as a class research project culminating a year's study of research design, literature search, laboratory procedures, and data analyses. The study area selected was entirely within the boundaries of the eastern rest stop, serving north-bound traffic heading for Washington D.C. some 32.2 km (20 mi) away. This facility has been in continuous use for approximately 13 years, presently serves a traffic flow of approximately 45,600 vehicles per day, and is projected to serve 63,500 traffic units per day (Patterson, 1977).

## Procedure

Seven pairs of students were each assigned specific transects (Figure 1) within the rest stop area. One soil sample was taken at each of five sites along each transect. A sample consisted of a soil column approximately one cm in diameter by five cm long, and devoid of surface detritus. All samples were oven dried, pulverized (45 mesh), and divided into four aliquots. All glassware was prewashed in hot concentrated  $\text{HNO}_3$  and rinsed first with dithizone then with water which had been deionized and extracted with dithizone/carbon tetrachloride solution. Each aliquot was extracted (20 minutes) with continuous shaking by 0.1 N HCl (Lindsay, 1972; Boawn et al., 1957; Giordano and Mortvedt, 1969). Soil finings were removed from the soil extract using a sintered glass filter. The solution was diluted to volume and aspirated into a Perkin Elmer 360 Atomic Absorption Spectrophotometer. Lead contents were determined at 283.3 nm and zinc at 213.9 nm. Data retention was determined at 90 percent confidence level by the Q test (Skoog and West, 1974). Significance of difference between mean concentrations of lead and zinc in sampling sites within each transect was tested by "Student's" *t*. Confidence levels were set at the 95



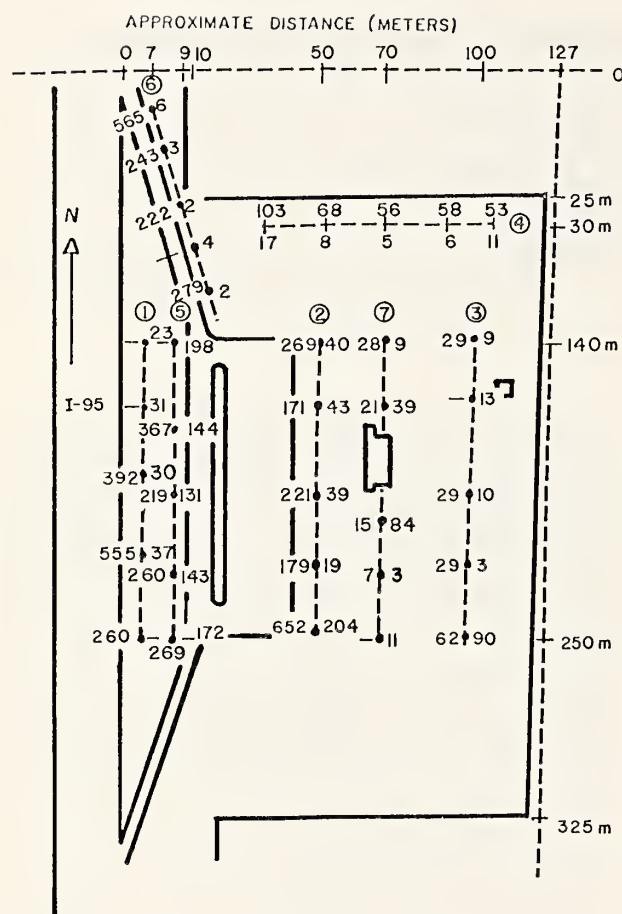


FIG. 1—Rest stop soils adjacent to I-95 at Dale City, Virginia were analyzed along seven transects. Soil lead concentrations (given at the left of each sampling point) ranged from 7 ppm to 578 ppm while soil zinc concentrations ranged from 2 ppm to 204 ppm. Traffic is northbound; prevailing winds are from the west; drainage is southward. Figure is not to scale.

percent level. The mean concentrations of zinc and lead at each sampling site are given in Tables 1 and 2. Confidence Intervals for those data were set at the 95 percent level and calculated according to Skoog and West (1974).

### Discussion

Some data points of the students had to be rejected based on criteria established by the Q test (at the 95 percent confidence level) (Tables 1 and 2), and some retained data showed unusually large Confidence Intervals (i.e. Table 2, Number 5, Sampling Point 2), all of which attest to the relative inexperience of the investigators. However, analyses for significance of differences between means (unmatched pairs)—the "Student's" t test—indicated that the transect lines did not happen to be laid out in soil regions of similar heavy metal content. Approximately 67.1 percent of sampling sites, compared within transect lines, had significantly different mean lead concentrations. About 75.5 percent of the mean zinc concentrations

within transects were significantly different. These results, of course, precluded any possible testing for differences between transects. More importantly, this information indicates that at least some of the lead and zinc certainly had arrived on-site through some mechanism other than the natural history of the soil.

That it is at least reasonable to assume that motor vehicles have been a major mechanism for site loading is obvious from the general pattern (Figure 1) which emerged where sites nearer the parking-traffic areas had higher extractable lead and zinc than more remote areas. Roughly speaking, the more remote soils had about 10 times less lead and 10 to 66 times less zinc than soils nearer the traffic-parking areas.

**Zinc**—The major source of zinc from motor vehicles is attributed to tire abrasion. In this study it was found that the highest concentrations of zinc (131 ppm to 198 ppm) occurred along Transect 5 (Figure 1). That transect is slightly downslope from and only one meter west of an uncurbed pavement edge used routinely for parallel parking by heavy trucks and trailer-towing autos. The only other exceptionally high zinc concentration (204 ppm) occurred at a drainage low point at the south end of Transect 2. Even these high concentrations, however, do not exceed the 10 to 300 ppm range of naturally occurring zinc in agricultural soils reported by Alloway and Davies (1971). In fact, except for 2 anomalies, soil zinc concentrations beyond the periphery of the paved parking area generally lie below the 50 ppm value Alloway and Davies cite as an "average" value.

If "background" soil zinc concentrations for the Ruston-Beltsville soils are fairly represented in samples taken within the easternmost transect (3 to 13 ppm), the maximum zinc accumulation from traffic exposure for 12 years (131 to 198 ppm) amounts to 10 to 66 times background levels, and that only in regions of constant high exposure. The soil along Transect 2 lies adjacent to a curbed, perpendicular-park area, and has accumulated only from 2 to 13 times the background (excluding the southernmost point) over the same period. More importantly, data from Transect 6 indicates that the compacted, well-drained, soil-roadbed gravel mixture lying there has accumulated virtually no zinc over the years.

Clearly only those narrow belts of rest stop soil subjected to direct and extensive loading have been able to act as zinc reservoirs, and accumulations there have not been excessive. Roadside gravels retained no significant amounts of zinc despite high exposures. Presumably a major portion of the zinc falling on the parking pavement bypassed all soil interactions by being washed to gutters and drained off-site through tiles. Since the southernmost point of Transect 2 is a natural drainage low point throughout a region of low relief in general, there is some reason to suspect that zinc interactions with this soil are slow, and surface drainage also may move the zinc off-site wherever slopes are significant and application rates moderate. Therefore, unless the design of the expanded rest stop facility specifically emphasizes a greater interaction between soils and traffic discharges, there is little reason to expect that the soil will retain significant amounts of zinc.

**Lead:** Soil lead accumulations and retentions also

TABLE 1

The mean concentration of zinc in the soil ranged from 3 ppm to 204 ppm and varied along each transect. The mean concentration in soil obviously mixed with roadbed gravel (Transect 6) ranged from 2 ppm to 6 ppm.

Transect Number	Mean $\pm$ 95% Confidence Intervals of Zinc At Each Sampling Point				
	1	2	3	4	5
1	22.7 $\pm$ 1.7	31.3 $\pm$ 11.5	30 $\pm$ 10.8	36.7 $\pm$ 7.1	a.
2	40 $\pm$ 31.9	43.5 $\pm$ 9.7	38.8 $\pm$ 4.0	19.0 $\pm$ 5.4	204 $\pm$ 43
3	8.6 $\pm$ .9	12.9 $\pm$ 12	10.4 $\pm$ 1.5	3.4 $\pm$ 57	90 $\pm$ 110.3
4	17.4 $\pm$ .52	7.67 $\pm$ .09	5.02 $\pm$ .41	5.79 $\pm$ .41	10.9 $\pm$ 1.12
5	198 $\pm$ 19.8	144 $\pm$ 21.8	131 $\pm$ 21.1	143 $\pm$ 8.1	172 $\pm$ 33.6
6	5.52 $\pm$ .36	2.64 $\pm$ .09	1.71 $\pm$ .91	4.2 $\pm$ .09	1.82 $\pm$ .37
7	9.48 $\pm$ .20	39.7 $\pm$ .15	84.5 $\pm$ 66.3	2.57 $\pm$ .93	11.1 $\pm$ 2.3

a. Student data rejected at the 90 percent confidence level using the rejection quotient Q (Skoog and West, 1974).

are functions of exposure. Based on the easternmost transect of this study, it is estimated that the background level of lead in the Ruston-Beltsville soil is around 30 ppm. This is comparable to the values given by John (1971) (700 natural soils averaging 51.9 ppm), Murrmann and Koutz (1972) ("natural" lead concentrations ranging from 2 to 200 ppm), and Roberts et al. (1974) (urban soils ranging from 100 to 500 ppm). Furthermore, this background value is approximately 10 times lower than the lead concentrations reported within the most highly exposed soils (Transects 1, 5, and 6). Interestingly, unlike zinc, lead accumulations are significant in the roadbed gravel-soil mixture sampled along Transect 6.

The accumulation of lead in the soil along Transects 2 and 5 averages 310 ppm. This level of lead content is somewhat higher than levels reported for other soils receiving high exposure. For example, 183 ppm soil lead has been reported at 7.5 m from roads carrying 35,200 to 54,700 vehicles per day (Motto et al., 1970). However, John (1971) argues that data reported by Motto et al. and others, based on acetic acid elutions, are in fact low and recommends eluting soil samples with HCl as was done in this study. In another study, Cannon and Bowles (1962) used emission spectroscopy to determine lead content of 6 garden soils less than 15 m from highways. They report lead concentrations ranging from 100 ppm to 1000 ppm. Nevertheless, the amount of lead retained in the Ruston-Beltsville soil remains but a fraction of the total exposure.

The lead emission rate from automobiles is esti-

mated to be between 0.06 and 0.18 g/km (Solomon et al., 1977). Thus the approximately 46,000 vehicles per day passing this 200-m stretch will emit from about 0.6 to 1.7 kg of lead per day, much of which can be expected to make its way onto that soil strip. This rate of exposure to lead has not been constant over the last 12 years, of course, but the average accumulated soil lead (310 ppm) in this approximately 1700-m<sup>2</sup> strip of land (to a depth of 5 cm) accounts for only around 39 kg of lead—barely 23 to 65 days' worth of emitted lead from passing automobiles (emissions from idling engines parked along this more-or-less continuously throughout each day are not being considered here).

Clearly, while the soil lead measurements reported here are consistent with values reported elsewhere, significant amounts of lead remain unaccounted for in the rest stop soil. Solomon et al. (1977) showed that lead in roadside dust is soluble to the extent of 500 to 1000 mg/l at pH 4—a value closely approximating the acidity of rains (pH 4.22 to 4.30) in this region (Likens, 1976). Thus the combined features of lead solubility and the inadequacies of rest stop soils to absorb lead indicate that significant amounts of lead will move on to nearby streams each year. This can be expected despite the continuing drop in gasoline lead over the years from 4 g/gal (before 1970) to 2.5 g/gal (1970) to 0.8 g/gal (1978) to 0.5 g/gal (1983 standards) (Anderson, 1978). These improvements will be more than offset by the increased lead discharges from the projected traffic flow of up to 63,500 units per day and the decreases in soil exposure re-

TABLE 2

The mean concentration of lead in the soil ranged from 7 ppm to 652 ppm and was highly variable along all transects. The mean concentration in soil obviously mixed with roadbed gravel (Transect 6) ranged from 222 ppm to 578 ppm.

Transect Number	Mean $\pm$ 95% Confidence Intervals of Lead at Each Sampling Point				
	1	2	3	4	5
1	a.	a.	392 $\pm$ 188	555 $\pm$ 224	260 $\pm$ 85
2	269 $\pm$ 19.4	171 $\pm$ 27.8	221 $\pm$ 16.4	179 $\pm$ 35.9	652 $\pm$ 156
3	29.1 $\pm$ 6.1	a.	29.2 $\pm$ 2.8	29.2 $\pm$ 5.4	62.2 $\pm$ 11.9
4	103 $\pm$ 7.8	68.0 $\pm$ 2.2	55.8 $\pm$ 1.8	57.7 $\pm$ 3.3	52.7 $\pm$ 3.1
5	a.	367 $\pm$ 278	219 $\pm$ 36.1	260 $\pm$ 111	269 $\pm$ 13.8
6	565 $\pm$ 139	243 $\pm$ 19.8	222 $\pm$ 68	a.	279 $\pm$ 57
7	28.3 $\pm$ 2.3	21.1 $\pm$ 11.2	15.4 $\pm$ 13.8	6.4 $\pm$ 17.7	a.

a. Student data rejected at the 90 percent confidence level using the rejection quotient Q (Skoog and West, 1974).



sulting from the gutters, storm drains, and off-site discharges of runoff designed into the expanded rest stop facility.

It remains interesting to speculate on whether or not the soil at this site could be usefully employed to retain significant amounts of lead over the years. The data presented here indicate that the Ruston-Beltsville soils are capable of retaining approximately 10 times background levels. In other studies both Cannon and Bowles (1962) and Motto et al. (1970) found mean maximum values of lead to be only two to three times background levels. Therefore, it may be that the maximum lead retentions in the Ruston-Beltsville soil approximate its capacity under high-exposure conditions. This argument is even more reasonable given the prevailing conditions of the acidity of local rainfall (Chaney, 1974; and Likens, 1976) and the modest Cation Exchange Equivalent (C.E.C.) of this soil (13.8 meq/100 g). Clearly, if all the soil on the site could be uniformly exposed to the lead discharges, significant quantities of that heavy metal could be retained over the years, but it still would be less than the expected discharges.

**Management possibilities**—Planning for the containment of lead (and other pollutants) by means other than soil absorption through chance contact is possible, of course. Solomon and Hartford (1976) reported that analyses of gutter dust along roads carrying 20,000 cars/day indicated that there was from 1 to 24 g Pb/m<sup>2</sup> street surface. For the approximately 6000 m<sup>2</sup> of pavement in the present rest stop and highway surfaces adjacent to this study, dusts might account for from 6 to 144 kg of lead. At least that proportion of lead (and zinc) falling on the parking area could be removed by periodic sweepings. In fact, such practices offer considerable other advantages as pointed out by Huntzicker, et al. (1975). Other options include covering the acid Ruston-Beltsville soil (Kaster and Porter, 1964) with soils of higher C.E.C. value and the impoundment of runoff (for BOD removal) then spraying the water back onto large areas of available soil (Garrigan, 1977). In this latter option, care must be taken to maintain soil pH at some value greater than pH 6.5 (Chaney, 1974). Containment of aerosols contaminated by lead and other heavy metals may be more difficult. The magnitude of this form of contamination is reviewed by Huntzicker, et al. (1975), Chow (1972) and Moyers et al. (1972) amongst others.

### Conclusions

As a practical extension and application of laboratory studies, third-quarter college chemistry students have documented the distribution of lead and zinc in the Ruston-Beltsville soil of this rest stop. Background levels of zinc were found to be approximately 3 to 13 ppm while those of lead were around 30 ppm. Zinc retention in a narrow belt of highly exposed soil ranged from 10 to 66 times background, while lead concentrations under similarly favorable conditions ranged around 10 times background levels. These values are unable to account for more than a fraction of the estimated on-site loadings; hence, it is expected that significant proportions of future lead and zinc loadings to this parking area will be lost off-

site in the absence of the adoption of specific management programs.

### Literature Cited

- Alloway, B. J. and Davies, B. E. (1971): Trace Element Content of Soils Affected by Base Metal Mining in Wales. *Geoderma* **5**(3): 197-208.
- Anderson, E. V. (1978): Phasing Lead Out of Gasoline: Hard Knocks for Lead Alkyl Producers. *Chem. Eng. News* **56**(6): 12-16.
- Boawn, et al. (1957): Plant Utilization of Zinc from Various Types of Zinc Compounds and Fertilizer Materials. *Soil Sci.* **83**: 219.
- Cannon, H. L. and Bowles, J. J. (1962): Contamination of Vegetation by Tetraethyl Lead. *Science* **137**: 765-766.
- Chaney, R. L. (1974): Recommendations for Management of Potentially Toxic Elements in Agriculture and Municipal Wastes. In *Factors Involved in Land Application of Agricultural and Municipal Wastes*. Nat'l Program Staff, Agriculture Research Service, Soil Water and Air Services, USOA, Beltsville, Maryland, pp. 97-120.
- Chow, T. J.; Earl, J. L. and Snyder, C. B. (1972): Lead Aerosol Baseline: Concentration at White Mountain and Laguna Mountain, California. *Science* **178**: 401-402.
- Garrigan, G. A. (1977): Land Application Guidelines for Sludges Contaminated with Toxic Elements. *J. Water Pollu. Control Fed.* **49**(12): 2380-2389.
- Giordano, P. M. and Mortvedt, J. J. (1969): Response of Several Corn Hybrids to Level of Water Soluble Zinc Fertilizers. *Soil Sci. Soc. Am. Proc.* **33**: 145.
- Huntzicker, J. J.; Friedlander, S. K. and Davidson, C. I. (1975): Material Balance for Automobile-Emitted Lead in Los Angeles Basin. *Environ. Sci. Technol.* **9**(5): 448-457.
- John, M. D. (1971): Lead Contamination of Some Agricultural Soils in Western Canada. *Environ. Sci. Technol.* **5**(12): 1199-1203.
- Kaster, D. L. and Porter, H. C. (1964): Soils of Prince William County, Virginia, Report No. 8, pp. 144-145.
- Likens, G. E. (1976): Acid Precipitation. *Chem. Eng. News*, Nov. 22, 1976, pp. 29-44.
- Lindsay, W. L. (1972): Inorganic Phase Equilibrium of Micro-nutrients in Soils. In *Soil Sci. Soc. Am. Proc.* (W. L. Lindsay, ed.), p. 41.
- Motto, H. L.; Daines, R. H.; Chilko, D. M. and Motto, C. K. (1970): Lead in Soils and Plants: Its Relationship to Traffic Volume and Proximity to Highways. *Environ. Sci. Technol.* **4**(3): 231-237.
- Moyers, J. L.; Zoller, W. H.; Duce, R. A. and Hoffman, G. L. (1972): Gaseous Bromine and Particulate Lead, Vanadium, and Bromine in a Polluted Atmosphere. *Environ. Sci. Technol.* **6**(1): 68-71.
- Murmann, R. P. and Koutz, F. R. (1972): Role of Soil Chemical Processes in Reclamation of Wastewater Applied to Land. In *Wastewater Management by Disposal on the Land* (S. Reed, Coordinator). Cold Regions Research and Engineering Laboratory, Corps of Engineers, U.S. Army, Special Report 171, pp. 48-76.
- Patterson, H. E. (1977): Draft Negative Declaration, Dale City Interchange. Environmental Quality Division, Virginia Department of Highways and Transportation. Federal Project 1-95-2(143)162. State Project 0095-076-112, PE-101. 30 pp.
- Roberts, T. M.; Hutchinson, T. C.; Pasiga, J.; Chattopadhyay, A.; Jervis, R. E. and Van Lood, J. (1974): Lead Contamination Around Secondary Smelters: Estimation of Dispersal and Accumulation by Humans. *Science* **186**(4169): 1120-1122.
- Skoog, D. A. and West, D. M. (1974): *Analytical Chemistry*, an Introduction, 2nd ed., Chap. 3, pp. 20-59. Holt, Rinehart and Winston, Inc., New York.
- Solomon, R. L. and Hartford, J. W. (1976): Lead and Cadmium in a Small Urban Community. *Environ. Sci. Technol.* **10**(8): 733-777.
- Solomon, R. L.; Hartford, J. W. and Meinkoth, D. M. (1977): Sources of Automotive Lead Contamination of Surface Water. *J. Water Pollu. Control Fed.* **49**(12): 2502-2506.

# Fatigue Damage: Stiffness/Strength Comparisons for Composite Materials\*

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## Introduction

This work was undertaken to establish how two damage mechanisms, fiber breakage and debonding, affect two critical parameters, percent stiffness reduction and percent strength reduction, for boron/epoxy laminates subjected to fatigue loading. A reduced stiffness analysis was used in conjunction with laminated plate theory to predict stiffness changes based on observed debonding and fiber breakage. Specimens used for strength analysis either fractured during the fatigue test or were loaded statically to failure after being fatigued. All specimens were leached with

a heated acid, and fiber breakage was recorded. Predicted and actual stiffness changes (both static and dynamic), percent fiber breakage, and percent strength reduction were compared for both short life-high load and long life-low load fatigue tests.

## Procedure

Tests were run on a servo-controlled, closed-loop, fatigue-testing machine. The specimens were held with 20,000-lb (89-kN) wedge grips. The grip faces were partially filled with epoxy and the specimen ends covered with medium-grit emery paper, thereby preventing slippage and unnecessary grip failures and eliminating the need for end tabs.

During the tests, many physical and material parameters were monitored, and, since fatigue is a dynamic real-time process, some factors such as load and strain were continuously monitored in real time. By means of several electronic systems and real-time data acquisition and reduction equipment, these factors were operated upon, and the following variables were supplied as outputs: maximum strain, load at maximum strain, and dynamic secant compliance  $C_d$ . A programmable calculator and digital processing oscilloscope were used to monitor the load and strain signals. A software package developed in-house controlled the data sampling and reduction. Static tests were also performed by using the same setup to establish initial strengths and fracture strains.

Specimens used for stiffness analysis were removed after fatigue and leached. The fibers in the  $0^\circ$  layers were counted. Their length, either between the grips or within the grips, and the end they were counted from, top or bottom, were recorded. Because of the shuffling that occurred during the leaching and cleaning process, multiple breaks could not be counted accurately. Therefore, throughout this report, percent fiber breakage will mean the percentage of fibers broken at least once. The percentage of broken fibers between the grips and in the grips was determined from both ends and averaged to get a reliable figure for the entire specimen. The fibers in the  $\pm 45^\circ$  layers were also counted, with only fibers between the grips being counted in such a way as to insure that all fibers in the 1-in. (25-mm) gage length were represented. Pieces of fibers were approximately matched as they were counted, and a single percentage of broken fibers was calculated.

\* A synopsis of the 1978 J. Shelton Horsley Research Award which appeared in full detail in the *Journal of Testing and Evaluation*, Vol. 5, No. 5, 384-393 (1977).



TABLE 1  
Summary of data for fatigue test sequences.

Test Sequence	Test Specimen Number	Maximum Cyclic Strain $\epsilon_F$ , %	Thousand Cycles, $n$	Stiffness		Strength		Broken Fibers	
				$\Delta E$ Experimental, %	$\Delta E$ Analytical, %	$\Delta \sigma_{ult}$ (Residual), %	$\Delta$ Strength (Fatigue), %	0 deg Including Grip, %	45 deg, %
A	11	75	1000	14.8	15.0	...	29.3 <sup>a</sup>	44.1	44
A	27	69	1023	9.3	8.4	...	37.4 <sup>a</sup>	19.2	38.2
A	21	66	1002	5.3	7.7	...	36.9 <sup>a</sup>	31.8	32.5
E	19	47	1000	4.0	...	5.1	...	18.4	...
E	34	45	1001	5.9	...	5.1	...	30.7	...
E	24	40	1015	2.6	...	1.8	...	23.9	...
C	35	86	10.5	4.3	7.0	...	23.3 <sup>a</sup>	32.2	38.6
C	16	85	15.5	6.0	6.5	...	22.0 <sup>a</sup>	27.9	34.1
C	33	79	20.1	6.7	7.1	...	20.2 <sup>a</sup>	24.4	34.2
D	20	85	21.4	6.3	7.3	2.1	12.2 <sup>a</sup>	23.4	...
B	6	90	12.4	7.2 <sup>b</sup>	...	...	16.8	20.6	...
B	13	85	22.3	10.6 <sup>b</sup>	...	...	23.8	27.0	...
B	18	80	137	8.7 <sup>b</sup>	...	...	22.1	30.0	...

<sup>a</sup>Percent reduction in maximum cyclic stress level at termination of fatigue test.

<sup>b</sup>Dynamic stiffness change.

The percentage of matrix damage in the other 0° layers was calculated as

$$\%M_1 = (\%F_1/\%F_0)\%M_0$$

where

$\%M_1$  = the percentage of matrix damage in the inner 0° layers,

$\%M_0$  = the percentage of matrix damage in the outer 0° layer that was photographed,

$\%F_1$  = the percentage of broken 0° fibers between the grips in the inner 0° layers, and

$\%F_0$  = the percentage of broken 0° fibers between the grips in the outer 0° layer that was photographed.

The approximately 200 four-mil (0.1-mm) diameter fibers found in the 0° layers, on the average, made up 82.8 percent of the width of the laminate if set side by side. The percentage of matrix damage in each layer was multiplied by 0.828 to estimate the percentage of fiber length where debonding had occurred and  $E_r = 0$ . This percentage was used to reduce  $E_{11}$ .

In the first test sequence, the percentage of matrix damage in the 45° layers was assumed to be 100 percent. This percentage was used to reduce  $E_{22}$  and  $G_{12}$ . The product of the percentage of matrix damage in the 45° layers and the percentage of broken fibers in the 45° layers was used for the percentage reduction of  $E_{11}$  in these layers. The data and results are summarized in Table 1. One should note that even though we have only dynamic stiffness changes to compare in this case, for approximately the same running strain in Case C the static and dynamic stiffness changes differed by only 3.8 percent at most, and as little as 0.4 percent for Case D Specimen 20. A comparison of results is also shown in Figure 1.

### Summary and Conclusions

By observing the results of five fatigue test sequences and noting correlations, we come to the following conclusions:

1. There is a strong correlation, both quantitative and in trend, between static stiffness changes and matrix-type damage, primarily in the amount of debonding and matrix cracking that is generated around fiber breaks during fatigue.

2. The percent reduction in strength based on initial static strength and final stress level at fracture for our laminate subjected to strain-controlled fatigue loading shows some correlation, both quantitative and in trend, with the percent 0° fibers broken during fatigue prior to final fracture.

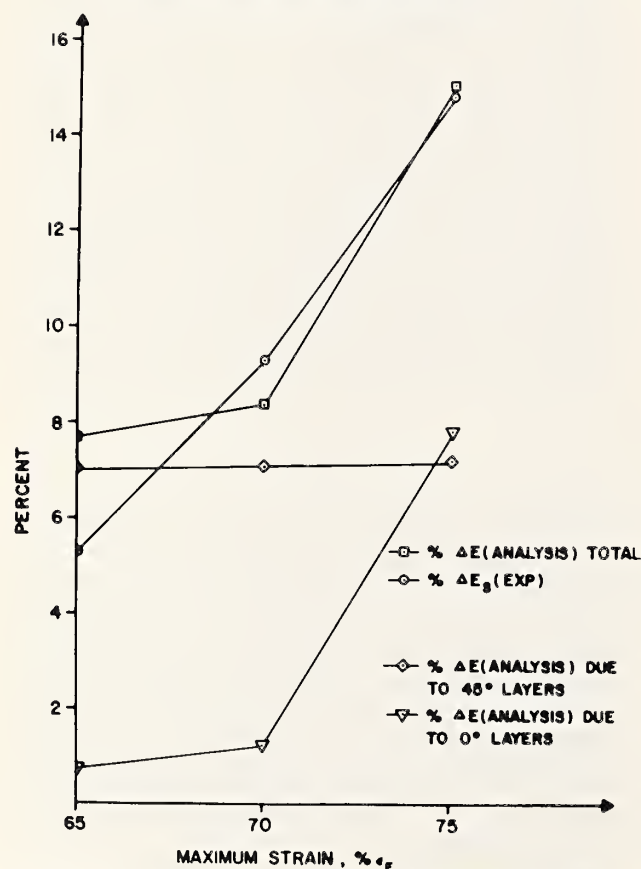


FIG. 1—Long life/low load (stiffness analysis) data and results.

# Degree Day Correction Factors for Thermostat Settings Different From 72° in Virginia

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## Introduction

Since the degree day method for calculating the heat load of residential dwellings was first formulated<sup>1</sup>, one of the major conditions of the study has changed in common practice. This changed condition is the practice of leaving room thermostats at an average of 72°F. If the media is to be believed, very few people are today heating their homes to such a high temperature.

Because of this change in behavior, there is a need for a correction factor for changing the standard number of degree days based on 72°F to one which corresponds to a lower average thermostat setting. This report contains such a compilation for the state of Virginia and a few Maryland sites.

## Correction Factors

To begin with, it must be specified that the standard degree day is defined with respect to a base temperature of 65°F. The value 65°F was determined experimentally to give the best description of a home with thermostat set to 72°F. In the absence of further experiments, one cannot be sure that base temperatures will always be 7°F lower than the average thermostat setting. This requires further experimentation. However, as a practical tool it is useful to determine the effective degree day for differing base temperatures through a geographical region. With the variation of the degree days known for different base temperatures, many applications can be made in practical situations.

Using the HISARS<sup>2</sup> data base maintained at VPI & SU by the Virginia Water Resources Research Center, the effective degree days for different base temperatures were averaged for 48 sites over the last 11 to 28 years. The functional dependence of the degree day as a function of the new base temperature was fitted to a simple form. This fit is good to five parts per thousand.

This data is represented by a correction factor which depends on the difference between the new base temperature and 65°F

$$\Delta T = T_{\text{base}} - 65^\circ$$

The correction factor is given in Table 1 by the three coefficients A, B, C, where A = 1.0, in the form

$$FC = 1 + B(\Delta T) + C(\Delta T)^2$$

This form is accurate to within 5 percent for a range of  $\Delta T$  of  $\pm 20^\circ\text{F}$ .

$$\begin{aligned} FC &= 1.0 - (0.053)(5) + (0.0007)(25) \\ &= 1.0 - 0.265 + 0.018 \\ &= 0.753 \end{aligned}$$

The effective degree days then will be

$$DD(60^\circ\text{F}) = (0.753)(4122)$$

As can be seen from the table for most of Virginia, an averaged expression can be derived from the table. The expression is

$$DD(t_b) = DD(65) \{1 + (0.053)\Delta T + (0.0007)(\Delta T)^2\}$$

This example will make clear how to use the table. Finally, a comment about how the fits were determined. Using the HISARS weather tapes, the high and low temperature for each site were combined to give the average temperature for the nth day  $\bar{T}_n$ . The difference between the base temperature  $T_b$  and  $\bar{T}_n$  was calculated and accumulated if  $T_b - \bar{T}_n$  was positive. The sum of these positive terms over the whole year was added to give the number of degree days for a given year.

The same process was repeated for as many years as there were complete temperature data for the specific site. Finally, for each base temperature an average of the effective degree days over the years was

<sup>1</sup> ASHRAE 1972 Book of Fundamentals, Chapter 27, *House Heating*, American Gas Association, Industrial Gas Series, 3rd ed.

<sup>2</sup> Hydrologic Information Storage and Retrieval System, *HISARS*, Written by E. H. Wiser, maintained by Virginia Water Resources Research Center, Blacksburg, VA 24061.



TABLE 1  
*Degree days and correction factor coefficients*

Weather Station	Degree Days (65°F)	A	B	C
Backbay	3732.	1.00000	0.06215	0.00095
Blackstone FAA	4090.	1.00000	0.05397	0.00074
Bristol	3852.	1.00000	0.05656	0.00082
Buchanan	4355.	1.00000	0.05198	0.00072
Cape Henry	3696.	1.00000	0.05825	0.00087
Charlotte C.H.	4348.	1.00000	0.05500	0.00084
Charlottesville	4225.	1.00000	0.05309	0.00068
Chase City	3928.	1.00000	0.05518	0.00074
Chatham	4362.	1.00000	0.05307	0.00070
Cheriton	3794.	1.00000	0.06018	0.00099
Chilhowie	5416.	1.00000	0.04879	0.00069
Chincoteague	4828.	1.00000	0.05277	0.00069
College Park, Maryland	4536.	1.00000	0.04621	0.00045
Columbia	4566.	1.00000	0.05151	0.00065
Covington	4799.	1.00000	0.05145	0.00069
Danville Bridge Station	3914.	1.00000	0.05596	0.00077
Farmville	4119.	1.00000	0.05565	0.00082
Floyd	4692.	1.00000	0.04979	0.00069
Fort Lee	4389.	1.00000	0.05209	0.00065
Galax	5111.	1.00000	0.05374	0.00078
Glen Lyn	4306.	1.00000	0.05184	0.00076
Hagerstown, Maryland	5222.	1.00000	0.04627	0.00055
Holland	3841.	1.00000	0.05843	0.00091
Hopewell	3414.	1.00000	0.05821	0.00080
Lawrenceville	3891.	1.00000	0.05403	0.00071

TABLE 1 Cont'd.  
*Degree days and correction factor coefficients*

Weather Station	Degree Days (65°F)	A	B	C
Lexington	4413.	1.00000	0.05338	0.00071
Lynchburg	4463.	1.00000	0.05169	0.00065
Marion Evap. Station	5061.	1.00000	0.05296	0.00084
Martinsville	4529.	1.00000	0.05175	0.00066
New Canton	4423.	1.00000	0.05286	0.00069
Newport News Press Bldg.	3382.	1.00000	0.06129	0.00094
Norfolk	3023.	1.00000	0.06259	0.00099
Norfolk WSO	3623.	1.00000	0.05863	0.00087
Painter	4171.	1.00000	0.05541	0.00078
Pennington Gap	4843.	1.00000	0.04987	0.00069
Powhatan	4435.	1.00000	0.05273	0.00073
Pulaski	5140.	1.00000	0.05282	0.00083
Richmond WSO AP	4147.	1.00000	0.05284	0.00070
Roanoke	4122.	1.00000	0.05292	0.00071
Roanoke WSO AP	4384.	1.00000	0.05235	0.00067
Rocky Mount	4805.	1.00000	0.04879	0.00055
Staunton Sewage Plant	4984.	1.00000	0.04941	0.00059
Washington, D.C.				
Dalecarlio Reservoir	4508.	1.00000	0.04969	0.00065
Washington National	4291.	1.00000	0.05111	0.00065
Washington, VA	5311.	1.00000	0.04708	0.00059
West Point	4061.	1.00000	0.05482	0.00078
Wise	5214.	1.00000	0.05058	0.00077
Wytheville	5114.	1.00000	0.04998	0.00071

taken. It is this average which is reported here and which has been fitted to the correction factor.

#### Acknowledgments

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# On Correcting For the Length of the Simple Pendulum

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**Abstract**—It is shown that for a simple pendulum of the practical laboratory type a correction for the length due to the moment of inertia of the spherical bob without a simultaneous correction for the mass of the supporting wire often introduces an error rather than a correction. An example is given of a pendulum which needs no correction.

## Introduction

Simple harmonic motion which has such wide applicability in scientific work (e.g. electrical engineering, chemistry, mechanics, medicine, etc.) is well exemplified by the simple pendulum which is almost universally treated in college textbooks of physics and mathematics. Appropriate corrections for the period of the simple pendulum with large amplitude of displacement can be made and also used for didactic purposes (Schery, 1976). In ordinary laboratory practice, for small amplitudes, this correction is usually negligible.

Often one finds a correction to the length of the simple pendulum made by taking account of the moment of inertia of the spherical bob (Alonso and Finn, 1967; Fernandes, and Galloni, 1968; Foch, 1967; Wall et al., 1972), yet the finite mass of the cord or wire which supports the sphere is neglected.

## The Supporting Wire

The supporting cord or wire of the simple pendulum has a finite mass. Thus, while it is true that accounting for the moment of inertia of the sphere itself tends to effectively increase  $L$ , the distance from the center of the sphere to the point of support at the knife edge, the mass of the wire tends to cancel this when the system is considered as a physical pendulum, and in many practical cases the period for the system is again that of the simple pendulum without the correction.

By writing,

$$T = 2\pi(L/g)^{1/2} = 2\pi(I/mgh)^{1/2} \quad (1)$$

where the expression for the period  $T$  of the simple pendulum is made equal to the expression for the physical pendulum, we find that

$$L = I/mh; \quad (2)$$

which is the condition for the length of the simple equivalent pendulum. The term  $I$  is the moment of

inertia about the point of support or knife edge of the system, and  $h$  is its distance from the support to the center of gravity.

The center of gravity  $h$  for the simple pendulum is given by:

$$h = [m_s L + (L - r_s) (\frac{1}{2} m_w)] (m_s + m_w)^{-1} \quad (3)$$

where:

$m_s$  = mass of the sphere

$m_w$  = mass of the wire

$m = m_s + m_w$

$r_s$  = radius of the sphere

The moment of inertia of the system,  $I$ , with respect to the knife edge is given by:

$$I = m_s L^2 + 2/5 m_s r_s^2 + 1/3 m_w (L - r_s)^2 \quad (4)$$

In order to demonstrate that for practical systems of simple pendulums the period given by  $T = 2\pi (L/g)^{1/2}$  can be equal to the period of the physical pendulum given by  $T = 2\pi (I/mgh)^{1/2}$ , we have made the following derivation which gives the appropriate wire diameter  $d_w$  in terms of its density  $\rho_w$  and the radius  $r_s$  and density  $\rho_s$  of the sphere for a given value of  $L$ .

On substituting Eqs. (3) and (4) in Eq. (2) we find

$$L = m_s L^2 + 2/5 m_s r_s^2 + 1/3 m_w (L - r_s)^2 \div [m_s L + m_w/2 (L - r_s)]$$

or

$$m_w (L - r_s) L/2 = 2/5 m_s r_s^2 + 1/3 m_w (L - r_s)^2$$

In the above,

$$m_w = (\pi d_w^2/4) (L - r_s) \rho_w$$

and

$$m_s = 4\pi/3 r_s^3 \rho_s$$

from which:

$$d_w^2/8 \rho_w (L - r_s)^2 L = 8/15 \rho_s r_s^5 + 1/12 d_w^2 \rho_w (L - r_s)^3$$

$$d_w^2/4 \rho_w (L - r_s)^2 [L/2 - (L - r_s)/3] = 8/15 \rho_s r_s^5$$

$$d_w^2 = 64/5 \rho_s r_s^5 \div (L - r_s)^2 \rho_w (L + 2 r_s)$$



and

$$d_w = (8 r_s^2 / L - r_s) [r_s \rho_s \div 5 \rho_w (L + 2r_s)]^{1/2} \quad (5)$$

A simple pendulum with a wire diameter given by Eq. (5) needs no correction for its length.

### An Example

For the sake of illustration consider a lead sphere ( $\rho_s = 11.3 \text{ g/cm}^3$ ) with a diameter equal to 2.54 cm and  $L = 100 \text{ cm}$ . Then the appropriate diameter for an iron wire ( $\rho = 7.5 \text{ g/cm}^3$ ) would be 0.08 mm and for a nylon cord ( $\rho_w = 1.1 \text{ g/cm}^3$ ), 0.21 mm. These are small but not unreasonable wire and cord diameters which a laboratory instructor might employ with a pendulum. A "correction" to the length of this particular simple pendulum would introduce an error; an even greater error would result with larger diameter wires or cords. Thus, in many real configurations of the simple pendulum, less error for the period often would be introduced by simply using the

elementary formulation  $T = 2\pi (L/g)^{1/2}$  rather than correcting only for the dimension of the spherical bob.

### Conclusion

Attempts to correct for the length of a simple pendulum as used in laboratory practice should be avoided unless due consideration is given to the mass of the supporting wire or cord.

### Literature Cited

- Alonso, M. and Finn, E. (1967): *Fundamental University Physics*, Vol. I, p. 358. Addison Wesley, Reading, Mass.  
 Fernandez, J. and Galloni, E. (1968): *Trabajos Practicos de Fisica*, p. 161. Editorial Nigar, Buenos Aires.  
 Foch, A. (1967): *Mecanique*, p. 361. Masson & Cie, Paris.  
 Schery, S. D. (1976): Design of a Simple Pendulum for Study of Large Angle Motion. *Am. J. Phys.* **44**, 666-670.  
 Wall, C. N. et al. (1972): *Physics Laboratory Manual*, p. 84. Prentice Hall, Englewood Cliffs, N. J.

## Research Accountability and Evaluation

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### Introduction

With the ever increasing use of public funds for research by Federal and state agencies, including institutions of higher education, and the increasing demand by tax payers to know how their taxes are

spent, accountability has become of greater concern to administrators and individual scientists.

During the bicentennial year of 1976, a subcommittee of Virginia Tech's Research Advisory Committee for the College of Agriculture and Life Sciences was formed and charged with the responsibility of developing recommendations on ways and means of achieving more accountability and rigorous evaluation of research projects and programs in the College. This was an outgrowth of the 1975-76 University's Self-Study, which recommended that criteria for identifying nonproductive research programs, both *within* and *between* departments, should be established at the college level.

The report that follows was developed by the subcommittee over a period of several months. It was approved by the Research Advisory Committee, Dean of the College, and Director of the Agricultural Experiment Station, and made available to all faculty members as guidelines for the future.

### Definitions and General Statements

*Accountability* involves appropriate and efficient use of allocated resources; compliance with laws and regulations dealing with safety of personnel, experimental animals, equipment and facilities; proper storage and disposal of hazardous and restricted materials; and ethics in dealing with co-workers, collecting and handling of data, and publication of findings.

Accountability for resources expended on research must be shared by the individual researcher; the research group or team, where more than one scientist is involved; the appropriate department head(s); director of the agricultural experiment station; and the deans of the college and research divisions. The major responsibility, however, must rest on the individual researcher or project leader and his department head.

Responsibility and accountability for *allocation* of resources to a research area or problem should be with the dean and director, in consultation with a college research advisory committee, and administered through one or more departments. Allocations should be consistent with the stated mission of the College and, at the same time, considerate of particular problem areas and potential returns.

*Evaluation* involves measuring or determining (1)



the quality, potential and relevance of activities, and determining the extent to which resources, organization and alignment of research elements serve the mission of the Agricultural Experiment Station and the University; (2) how effectively each of the program elements contributes to the attainment of the specified goals; (3) how changes in the level of activity or quality of performance over a period of time affect the attainment of specified goals; (4) what proportion of the goals have been reached and what progress has been made toward reaching the other goals; (5) to what extent results of present research open doors to new areas that need investigation; and (6) if research results have been presented at professional meetings and/or published in scientific journals.

The fundamental issues of the review and evaluation process are those of value, quality and effective use of resources.<sup>1</sup> *Value* deals with the nature and importance of the program's goals as they relate to the needs and goals of the several publics served. *Quality* involves assessment of: (1) the extent to which a program achieves its goals; (2) its strengths and weaknesses; (3) the research faculty and their scholarly and service activities; and (4) the application of the research findings to the related industries of the state, the nation and beyond. *Most effective use of resources* requires the determination of the appropriateness of allocations and the organization of human and physical resources and decisions on whether and how to modify, expand, contract, initiate or eliminate program components.

Several parties learn from the joint review and evaluation process: the individual researcher, research team, persons involved in administrative tasks, and those who must represent the program to the university's constituencies. However, program improvement depends in large measure on the sensitivity, understanding, commitments and action of those involved in the research program itself. Therefore, review and evaluation should include:

1) *A self-study*—to increase the consciousness of the contributions of each program participant and to provide a basis for eliminating unprofitable aspects, changing directions, placing more emphasis on certain areas, preparing written reports and gaining greater perception of the total research efforts. Emphasis should be on evaluation rather than on data collection. Even though it is more difficult, it is also considerably more valuable to explain what the data mean, to measure the current status of the research program, to project goals and to determine the kind of change and support needed to reach these goals.

2) *An external review*—in many cases, evaluation of peers outside the program can contribute significantly to the identification of strengths and weaknesses and to the evaluation of projected courses of action. The external review committee might come from other qualified personnel within the college or university, but it most likely should come from other nationally recognized institutions, who after studying the report provided by the self-study committee would conduct an on-site visit and provide an oral and written report of their evaluation. The self-study

report should serve as a foundation document of the visit by the external review and evaluation committee.

In both the self-study and evaluation reports, special attention should be given to the following items in regard to:

#### A. Value

- 1) How appropriate are the goals to the experiment station's mission, the university, to Virginia and the nation?
- 2) What is the potential of the research for generating new knowledge or for extending, reinterpreting or applying existing knowledge?
- 3) To what extent are the goals congruent with or purposefully different from those of peer programs in other institutions?
- 4) To what extent does this research contribute to a balanced program of basic and applied research at Virginia Tech?

#### B. Quality

- 1) To what extent is the project meeting its goals?
- 2) What are the overall strengths and weaknesses?
- 3) How do researchers in related disciplines regard this research effort?
- 4) What professional honors or awards have been received by the researcher or research group?
- 5) Does this research contribute to graduate student training?
- 6) Have results of this research been published in scientific journals or presented at professional meetings?
- 7) To what extent are the researchers known as leaders in their discipline?
- 8) How successful have the researchers been in obtaining external support for their research and other scholarly activities?
- 9) How does this compare to peer workers at Virginia Tech and comparable institutions?

#### C. Effective Use of Resources

- 1) Is the generation of new knowledge commensurate with the resources expended?
- 2) What new or revised goals or areas of activity should be emphasized in order to make the program more effective?
- 3) Is additional financial support needed to accomplish the goals within a reasonable period of time?
- 4) Can some aspects of the research effort be accomplished more efficiently by other groups or through contracts?
- 5) Are there other resources on campus that could add to the effectiveness and efficiency of this project?
- 6) How appropriate are current administrative arrangements to the program's goals?
- 7) Is the current research faculty adequate to obtain the goals?
- 8) Is the technical and graduate assistant support adequate?
- 9) To what extent does this research program

<sup>1</sup> Borrowed heavily from the Ohio State University Program Review Guidelines, dated 12/2/76.



contribute to the college and university goals? What additions or improvements are needed?

- 10) To what extent are current physical facilities, experimental animals, etc., appropriate and adequate for the current activities?

Evaluation involves relating activities to goals. The goals of each individual researcher should be identified, as well as the goals of the group. Primary emphasis should be placed on identifying group goals where several researchers are involved in a research program and on determining the relative priorities of those goals.

Finally, accountability and evaluation of the research efforts and results must be related to time, resources allocated and facilities used.

### Comments and Recommendations

(1) Good research depends on clearly defined objectives and qualified, enthusiastic, dedicated researchers. Therefore, the department heads and experiment station administrators should be extremely careful in the selection of new personnel. Prospective new personnel should be well informed about the departmental objectives and should have those qualifications, including interest, which would enable them to make a major contribution toward reaching those objectives. Once employed, emphasis should be on providing an environment conducive to productivity.

(2) Accountability and evaluation must be shared by the college, the department and the individual researchers. Major responsibility for allocation of research funds should be at the college and department head levels, but once allocated, the major accountability should remain with the individual researcher.

(3) More effort should be made by the College and the several subject matter departments in determining research goals within specified time periods and in establishing priorities to reach these goals. Their goals and priorities should be reviewed periodically with agricultural leaders in order to assure that the research needs are addressed.

(4) It is recommended that the College issue broad guidelines for research accountability and evaluation, but since flexibility is essential, the details for carrying out the broad guidelines be left to the individual departments.

(5) It is recommended that each department prepare a written document (1) setting forth the department's goals and objectives, and (2) describing the department's procedures for handling research accountability and evaluation.

(6) Each researcher should be provided with at least the minimum operating funds necessary to carry out his or her approved project objectives. At the same time, they should be encouraged to seek other sources of funding to strengthen and broaden their overall research programs. Once allocated, they should be expected to operate within their budget, but given maximum flexibility in expending funds to meet the stated objectives.

(7) Each department should strive for objectivity in its accountability and evaluation procedures to

achieve maximum overall research effectiveness, taking into account:

- (a) The relevance, scope and complexity of the research effort.
- (b) The amount of support available.
- (c) The number and quality of publications.
- (d) Graduate Students trained.
- (e) Inventions, improvement and/or development of new varieties or breeds of plants and animals.
- (f) Research progress made as indicated in the SEA-CR reports.
- (g) Service rendered to the department, college, university, state and nation as indicated in the faculty service review form.
- (h) Grants and contracts generated.
- (i) Professional status, as indicated by important committee assignments, offices held in professional societies, awards received, and invitations to participate in special programs.

However, it is recommended that a point system not be developed in an attempt to score and weight these activities. It is realized that considered judgment, based on experience, is an essential part of evaluation.

(8) Faculty members with low productivity should be prodded into more productivity by (a) more judicious use of the merit system in salary increases and promotions; (b) encouragement by the department head and dean or director to drop the least productive projects, change directions, and search for new area of interest, new projects, new approaches and new sources of funds; and (c) as a last resort, termination of employment.

(9) It is recommended that each department conduct a self-study at approximately five-year intervals, to be followed by an external review similar to that described earlier in this report.

(10) The subcommittee agrees with the decision to appoint a special committee charged with the task of reviewing new and revised project proposals. This special committee should also be responsible for monitoring progress periodically, for making recommendations on all research projects of the Virginia Agricultural Experiment Station within the CRIS system, and for assisting the dean and director in establishing research priorities. The composition of this committee might be four faculty members, two department heads and a representative of the dean and director's office for a maximum of seven members.

### Acknowledgments

The authors express their sincere appreciation to all members of the Research Advisory Committee, especially to subcommittee members Joseph Havlicek, Jr., Norris L. Powell, and Patrick F. Scanlon; Dean James R. Nichols, Director Coyt T. Wilson, department heads, the numerous individual researchers who read the report and made revisions and to those from other land-grant institutions who were so generous in supplying assistance during the course of the committee's work.



*Report***Coal and Energy Needs and Issues in Virginia***(A Summary of Workshop Held November 8-9, 1978)*

The Virginia Center for Coal and Energy Research, the VPI & SU Research Division, and the State Office of Emergency and Energy Services co-sponsored a workshop on Coal and Energy Needs and Issues in Virginia on November 8-9, 1978 at the Donaldson Brown Continuing Education Center, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. It was attended by 69 representatives of industry, government, universities and public organizations.

*W. J. Fabrycky*, VPI & SU Dean of Research, welcomed the attendees and urged them to participate freely in open discussions to express all ideas. *E. F. Wilson*, representing the Commonwealth's Department of Commerce and Natural Resources, emphasized the need for careful energy planning and the need to let the market forces work. *William Jeffrey* of the Department of Highways and Transportation discussed the coal haul system and the need for road maintenance in Virginia. *Grant Hollett* of the Division of Mined-Land Reclamation discussed the cost of reclamation, its benefits, and the need for additional dirt-moving engineers. *George Jones*, Director of the Office of Emergency and Energy Services, stressed the need for policy development and realignment of conflicting policies; he also discussed the need to participate in the national and regional scene to reach proper decisions.

*J. W. Kepner* of Appalachian Power discussed the rising costs of equipment and fuel, the difficulties in capital formation and the demise of the power reserve in the future. *Peter Marozzi* of the United Coal Company emphasized the high cost of implementation of the new Surface Mine Control and Reclamation Act, and the need for research to evaluate the regulations and the loss of overseas markets.

Before dinner, there were tours to see the Small Fluidized Bed Combustion Project, the Solar Heating and Wind Energy Experiments, and the Rock Mechanics Laboratory. After dinner, *Senator Harry Michael* of Charlottesville, Chairperson of the Commission on Coal and Energy Research, described the work of the Commission and stressed the need for a national solution to the energy problem. *Stanley Ragon* of VEPCO identified the need for more coal and nuclear power facilities and discussed the high investment costs and the difficulty in attracting investors.

Next morning, *Michael Bishara* of the Southwest Virginia Community College opened the discussion on the nature of energy-related research at the universities. His presentation was followed by descriptions of the small coal combustion project (*Phil Mason*,

VPI), the environmental evaluation project (*Albert Hendricks*, VPI), the energy extension information projects (*Sam Bowen*, VPI), the regional energy analysis (*Sid Roberts*, ODU), the solar energy; wet scrubber and fluidized bed gas distribution projects (*Sterling Vines*, U. Va.), the gasoline consumption project (*Antoine Hobeika*, VPI), the energy simulation modeling and forecasting project (*Leo Rapport*, VPI), the project on social behavior and attitudes towards energy situation (*Scott Geller*, VPI), and burning of coal as an ablation phenomenon (*Clark Lewis*, VPI). Dr. Bishara provided the overview and summary of the session, strengthening the role of university research and the need for industry to identify problems which need translation into research projects.

*Fran Kieffer* of the League of Women Voters described the League's consensus on energy concerns and emphasized that they can now speak out on issues such as Virginia's lack of a long-range plan. *Joe Kaestner* of the Energy Advisory Council described their studies on energy issues including (1) conservation, (2) effect of regulatory processes on efficiency of utilities, and (3) lack of performance data. *Rev. Richard Austin* of the Coalition of Appalachian Energy Consumers attacked VPI & SU and Appalachian Power for the environmental study of the possible pumped storage facility in Bumley Gap. *Robert Pusey* of Va. Tech's Extension Division discussed quadruple A's of Energy: Awareness, Alternatives, Analysis and Action. *Delegate Don Dunford* of Tazewell presented the closing remarks.

At lunch, a survey of the workshop participants showed that the major energy issues facing the Commonwealth include (1) the need for alternative coal mining techniques, (2) the need for a coordinated enlightened energy policy, (3) the need for public awareness, and (4) the need for policy to consider the realities and needs of Virginians. The consensus was that the Commonwealth does face a severe energy situation. It was also evident that the combined efforts of industry, utilities, state government, and universities are needed to assure that the energy requirements of Virginians will be met in the coming decades.

The more detailed proceedings of the Workshop are being prepared and will be available from the sponsors.

*Walter R. Hibbard*, Director  
*Samuel P. Bowen*, Asst. Director  
 Virginia Center for Coal and  
 Energy Research

## Report

# Science Education Committee Activities

Each year since it was founded to promote science education and assist in the planning of the annual State Science Teachers Conference and Workshops, the Academy's Ad Hoc Committee on Science Education has participated in planning of meetings held at Williamsburg, Fredericksburg, and Roanoke. These meetings, held in October, are attended by secondary science teachers and have, for several years, been jointly sponsored by the Virginia Association of Science Teachers, the Virginia Academy of Science, and the original founders, the State Department of Education, Office of Supervisor of Science.

The 1978 meeting was held October 27 and 28 at the Hotel Roanoke and was attended by approximately 400 science teachers from middle and senior high schools across the state. The Friday program was opened with welcoming addresses from Mr. Sam Level, President of VAST; Dr. M. D. Pack, Superintendent, Roanoke City Public Schools; Dr. Dale V. Ulrich, President, Virginia Academy of Science; and Mr. Franklin D. Kizer, Science Supervisor, Virginia Department of Education. The principal address was given by Dr. Joanne M. Simpson, Professor of Environmental Sciences, University of Virginia. Dr. Simpson presented up-to-date information about scientific experiments designed to change weather by cloud seeding. Dr. Simpson concluded her very fine presentation with a splendid color, sound film which documented some of the cloud-seeding experiments conducted over the Florida everglades.

The workshops started Friday evening and embraced the topics: "Medical Studies of Venoms and Toxins" by Lt. James A. Vick, U.S. Army; "Simple Physics Demonstrations for Your Classroom" by Drs. D. Rae Carpenter and Richard Minnix; "Students as Laboratory Assistants in High School Science" by panelists: Mrs. Dorothy Domeruth, Mrs. Vera B. Remsburg, Mr. Robert R. Swann and moderator Mrs. Shirley A. Raines; and "The TIDLT" by Mr. Scott A. Rogers. On Saturday, in addition to the above, the following workshops were offered: "Chemistry and Its Applications in Forensic Science" by Mr. Ted Robinson; and "Middle School Science Project" by Dr. Edwin P. White.

For this 1978 meeting, the Academy's Science Education Committee arranged a special series of lectures and classroom activities entitled "Weather Prediction and Modification." This course was offered through the School of Education, University of Virginia, as a graduate course in Earth Science-Meteorology and two dozen teachers registered for graduate credit. Drs. Robert H. and Joanne Simpson were assisted by Dr. R. Wesley Batten of the Mathematics and Science Center, Richmond, Mrs. Ida Beaton of Chesterfield (Science Teacher, Robious Junior High School,) and Mr. P. K. Black of Henrico (Asst. Principal, Maude Trevvett Elementary School).

The teachers who registered for the special course

offering were enthusiastic in their participation in this unique opportunity for graduate credit in the field of meteorology.

The Science Education Committee met on November 12, 1978, at Bridgewater College on the occasion of the fall Council meeting of the Academy, to initiate planning for workshops and special courses to be offered at future annual fall Virginia State Science Teachers Conferences. The next meeting will be the Seventeenth Annual conclave and will be held at the Cavalier Hotel, Virginia Beach, Virginia on October 5-7, 1979. Academy members interested in attending or helping with this meeting should contact Dr. Joseph Exline, State Department of Education, Richmond, VA 23216 or Miss Virginia C. Ellett and Dr. Arthur W. Burke, Jr., Co-chairpersons, Committee on Science Education, c/o, Mathematics and Science Center, 2200 Mountain Road, Glen Allen, VA 23060.

*Virginia C. Ellett*  
Math. and Science Center  
and  
*Arthur W. Burke, Jr.*  
MCV-VCU

## *In Memoriam*

# Edward Felix Turner, Jr.



Dr. Edward Felix Turner, Jr., a member of Council and the 49th President of the Virginia Academy of Science, died in Charlottesville, Virginia on September 30, 1978 after an illness of several months. He had been associated with the Physics Department of Washington and Lee University since 1957.

He was born in Newport News, Virginia on April 21, 1920 and reared in Waynesboro. He entered Washington and Lee to study journalism but soon became interested in physics, receiving a B.S. in physics and a B.A. in mathematics in 1950. Massachusetts Institute of Technology awarded him an M.S. in 1952, and he obtained a Ph.D. in physics from the University of Virginia in 1954 for work performed under the late Jesse W. Beams, the Academy's 25th President.

From 1954 to 1957 he was Assistant Professor of Physics at George Washington University. In 1957 he returned to his alma mater, becoming the department head in 1961.



In the decade following receipt of his doctorate he did summer research for the Naval Research Laboratory, Diamond Ordnance Fuze Laboratory, VMI Research Laboratories, and Savannah River Laboratory.

Ed served the Academy in a variety of elected and appointed offices for over 16 years. When the position of council representatives from sections was instituted in 1962, he became the first such Council member from the Astronomy, Mathematics and Physics Section. Later he was elected Secretary, Chairperson and Editor in that section. In 1968, he was elected Academy Secretary, and again in 1969. Following his term as President in 1971-72, he served on the Nominating Committee, and the Ad Hoc Science Advisory Committee. He was Chairperson of the Constitution and Bylaws Committee at the time of his death. He was named a Fellow in 1975.

In addition to the Academy, he was a member of the American Physical Society, American Association of Physics Teachers, American Mathematical Society, and the American Association for the Advancement of Science. His honors included election to Phi Beta Kappa, Sigma Xi, Sigma Pi Sigma, Phi Eta Sigma and Raven Society.

He was active in his church as a Sunday school teacher, and he had done an extensive study for the Washington and Lee University in applying computer technology to libraries. He maintained an active interest in astronomy and in microcomputers in addition to serving as Chairperson of the Computer Committee.

Ed's commitment to the Academy was one of long standing and of depth. He was admired by Council for his thoroughness in solving problems and his understanding for a diversity of opinions. As a traveling companion he was unexcelled. His alertness to the world about him constantly triggered his posing a physical or mathematical problem with a subsequent analysis including expert mental arithmetic.

In his institution, his church, his community, and within his family, Ed's breadth of knowledge and of interests, his love of people and of learning, have left their indelible imprint on students, faculty, friends, and family.

*D. Rae Carpenter, Jr.*  
Past President, VAS

## Feature

### Meet Your Section Editors

J. Van Bowen, *editor*, VAS section on *Statistics*, was born in Richmond, Va. on February 11, 1942. He received his B.S. (1964) in mathematics from the U. of Richmond, and M. S. (1966) and Ph.D. (1968) from VPI & SU. During his 11-year professional career at his alma mater, he has also held faculty positions at MCV and VPI.

He has developed what is now a very popular course in statistics in which social science majors participate in a hands-on correct application of the most misinterpreted concepts of statistics to issues of social and societal concern. His principal research interests are in the maximum likelihood estimation of param-

eters using grouped data samples. His recent findings have led to publication and expert testimony in discrimination trials.



Dr. Bowen is a member of the American Statistical Association, American Mathematical Society, Fire Protection Engineers, Mathematical Association of American,  $\phi\kappa\phi$ ,  $\Gamma\mu\epsilon$ , and Virginia Academy of Science.



Samuel P. Bowen, *editor*, VAS section on *Astronomy, Mathematics and Physics*, was born in Council Bluffs, Iowa in 1939. He received his B.S. (1962) in physics with minors in mathematics and philosophy of science from Iowa State University, and Ph.D. (1967) from Cornell University. At VPI & SU, he holds the positions of the Associate Professor of Physics and Assistant Director of the Virginia Center for Coal and Energy Research.

He has diversified research interests which include many-particle theory, low temperature physics and solid state theory, and properties of transition metals. Most of his current efforts are devoted to research and extension (educational) activities related to the energy crisis.



Jim Campbell, *editor*, VAS' section on *Space Science and Technology*, received his B.S. (1963) from Mississippi State University, M.S. (1968) and Ph.D. (1973) in Aerospace Engineering from VPI & SU. He is presently Head of the Applied Aerodynamics Group in the Subsonic-Transonic Aerodynamic Division at NASA Langley Research Center. His



group is engaged in experimental and theoretical research programs to improve aerodynamic technologies applicable to commercial and military aircraft. The group conducts experimental research utilizing the high speed 7 by 10-foot tunnel to study configuration concepts, basic flow interference effects, and theory verification.

Dr. Campbell is a member of the American Association for the Advancement of Science, the VAS, and an Associate Fellow of the American Institute for Aeronautics and Astronautics.



Walter R. Hibbard, Jr., *editor*, VAS section on *Engineering*, is a University Distinguished Professor of Engineering and Director of the Virginia Center for Coal and Energy Research at Virginia Polytechnic Institute and State University, Blacksburg, Virginia. In 1974, he served as Deputy Director and Specialist on Fossil Fuels in the Energy Research and Development Office of the Federal Energy Office. From 1968 to 1974, he was Vice President of Technical Services in the Owens-Corning Fiberglas Corp., Toledo, Ohio. Dr. Hibbard is a member of the Board of Directors of the Norton Co. in Worcester, Massachusetts.

He served as Director of the Bureau of Mines in the U.S. Department of the Interior, Washington, D.C. from 1965 to 1968. Prior to this appointment, he was Manager of the Metallurgy and Ceramics Department of General Electric Research Laboratory, Schenectady, New York. After serving as a reserve officer in the U.S. Department of the Navy's Bureau of Ships during World War II, Dr. Hibbard taught metallurgy in the School of Engineering at Yale University. He also served as an Adjunct Professor of Metallurgy at Rensselaer Polytechnic Institute.

Dr. Hibbard is a member of the National Academy of Engineering and has served on its committees on Public Engineering Policy. He was Chairperson of the Materials Advisory Board and also the Building Research Advisory Board of the National Research Council. He served on the National Academy of Sciences Committee on the Survey of Materials Science and Engineering (COS-MAT). He is a Fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the American Ceramic Society, the American Society for Metals, the New York Academy of Science, and the Metallurgical Society of A.I.M.E. He was President of the American Institute of Mining, Metallurgical, and Petroleum Engineers for 1967-1968, and he received their James Douglas Gold Medal and Rossiter W. Raymond Award.

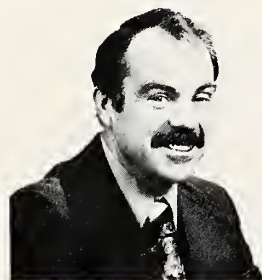
He graduated from Wesleyan University with a de-

gree in chemistry and received his doctorate in engineering from Yale. He has received honorary degrees from Michigan Technological University and from Montana College of Mineral Science and Technology. He is a registered professional engineer in the states of Virginia, Ohio and Connecticut.



Charles H. O'Neal, *editor*, VAS section on *Medical Sciences*, received his B.S. (1957) degree in chemistry from Georgia Institute of Technology and Ph.D. (1963) in biochemistry from Emory University. His professional experience includes being head of the technical instruction branch at U.S. Army Chemical Corps' Chemical Replacement Center, Atlanta, Ga.; a scientist at National Institute of Health's Laboratory of Biochemical Genetics, Bethesda, Md.; and a visiting scientist at Cambridge University's Laboratory of Molecular Biology. He joined the faculty of the Rockefeller University in 1965, and since 1968 he has been an Associate Professor of Biophysics at the Medical College of Virginia, Virginia Commonwealth University.

Dr. O'Neal is a Fellow of the American Institute of Chemistry. He holds memberships in the American Chemical Society, Biophysical Societies of the USA and UK, American Association for the Advancement of Science, Sigma Xi, and Virginia Academy of Science. He is a past President of Virginia Institute of Chemists, and MCV chapters of Sigma Xi and AAUP. He has notably served the Academy in his capacities as a past Editor of the Virginia Journal of Science and member of the VJS Editorial Board and Publications Committee.



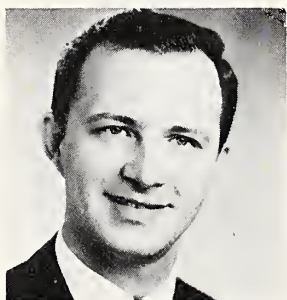
Patrick F. Scanlon, *editor*, VAS section on *Biology*, was born in Athlone, Ireland in 1941. He received the B. Agr. Sc. (1965), M. Agr. Sc. (1966), and Ph.D. (1970) degrees from the National University of Ireland. During 1969-1971, he was a research Associate at the University of Guelph, Ontario, Canada. Since 1971 he has been on the faculty of VPI & SU, where he holds the rank of Professor in the Department of Fisheries and Wildlife Sciences.

Dr. Scanlon's research and instructional interests include reproductive physiology, environmental con-



tamination, and vertebrate pest management. He has authored over 70 papers in these areas. He is a member of: The Wildlife Society, American Society of Mammalogists, American Society of Animal Science, and The Society of the Sigma Xi.

Dr. Scanlon has served the Virginia Academy of Science in his capacities as Secretary, Chairman and Editor of the Biology Section.



R. Jay Stipes, *editor*, VAS section on *Agricultural Sciences* received his B.S. (1958) from Waynesburg College, M.S. (1961) from West Virginia University

and Ph.D. 1965) from North Carolina State University. Prior to coming to Virginia Tech's Department of Plant Pathology and Physiology in 1967, where he holds the rank of Associate Professor, Dr. Stipes was a Research Plant Pathologist for the United States Department of Agriculture.

Dr. Stipes holds appointments in the research, instruction and extension divisions of the University. He has served as the major professor for 17 graduate students working towards their M.S. and Ph.D. degrees. He has developed several graduate level courses. His instructional and research interests are in the areas of tree pathology, fungitoxiology and mycology. He has authored or co-authored 131 scientific papers, and is currently working on two major scientific monographs.

Dr. Stipes is a member of several professional societies, holding offices in many of them, including the Agricultural Sciences and Botany Sections of the Virginia Academy of Science. He serves in editing capacities for a number of scientific journals, and is a widely sought consultant on tree diseases.

*Vivian Welker*  
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## NEWS AND ANNOUNCEMENTS

### MEMBERSHIP POLLED ON VJS

Concerned with the cost of publishing the Virginia Journal of Science as compared to the membership dues, the VAS Council, at its meeting held on May 12, 1978, charged Dr. Jack A. Wise, the Chairperson of the Publications Committee, to conduct a poll of the membership regarding the future of the Journal.

Approximately 37 percent of the membership returned 490 questionnaires; two-thirds responding within 2 weeks. The overwhelming majority of responders wish the Journal to continue beyond 1980; 74 percent are satisfied with the Journal, and 55 percent are not opposed to a page-charge. Seventy-nine percent favor more than 30 percent of dues allocated for the Journal, while 71 percent wish the yearly cost per member to be \$10 or less. The Editor finds this kind of prompt and favorable response encouraging for the future of the Journal.

However, an interesting observation emerges from the cost of dues figure quoted above and the more precise figures of 38 percent of the polled members favoring a \$10 yearly cost per member and 40 percent favoring an allocation between 30 and 35 percent of the dues. For these figures to be consistent, the dues would have to be raised to \$30 yearly—a conclusion likely to be disastrously unpopular for the Academy.

### STEWART WARE NAMED NEXT EDITOR OF THE VJS

Dr. Stewart A. Ware is the Editor of the Virginia Journal of Science, starting with the Spring 1979 issue (Vol. 30, No. 1).

Dr. Ware is an Associate Professor and Chairperson of the Biology Department at the College of William and Mary. He received his B.S. (1964) and Ph.D. (1968) degrees from Millsaps College and Vanderbilt University, respectively. His research interests include environmental control of plant distribution and vegetation of Virginia.

Dr. Ware is a former Co-Editor of the Jeffersonian. He has served on the Academy's Publications Committee and he led to the founding of the Botany Section.

Manuscripts for publication in the VJS should be addressed to:

Dr. Stewart A. Ware, Editor  
Virginia Journal of Science  
c/o Department of Biology  
College of William and Mary  
Williamsburg, Virginia 23185

He can be reached for inquiries by phone at (804) 253-4240.



# PAPERS TO APPEAR IN THE SPRING 1979 ISSUE

Distribution and Nature of Carolina Bays on the Eastern Shore of Virginia. *D. E. Perry, J.H. Scott, Jr. and D.J. Bliley*, Mississippi State University.

Forests of Small Stream Bottoms in the Peninsula of Virginia. *Susan Glascock and Stewart Ware*, College of William and Mary.

The Effect of a Thermal Discharge on the Benthos of a Virginia Creek. *Donald K. Gartman*, Columbia Gas System Service Corporation, and *Robert W. Lake*, University of Delaware.

More Oribatid Mites in the Vicinity of Mountain Lake Biological Station, Virginia (Acariformes: Oribatida). *Howard C. Sengbusch*, State University of New York, College at Buffalo.

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## NOTES



# NOTES

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The Virginia Journal of Science welcomes for consideration original articles in the various disciplines of engineering and science. Cross-disciplinary papers dealing with advancements in science and technology and impact of these on man and society are particularly welcome. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

Articles (other than abstracts, correspondence and comments, and news and notes) should be sent to the Editor, Dr. Kuldip P. Chopra, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA. 23508. Manuscripts dealing with science and society, history of science and technology, correspondence, and news and notes should be addressed to the Associate Editor, Dr. Michael N. Bishara, Engineering Division, Southwest Community College, Richlands, VA. 24641. Short notes (not exceeding eight double-spaced typed pages, 2500 words or equivalent including illustrations) may be sent to the Editor or one of the members of the Editorial Board. Proofs, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

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